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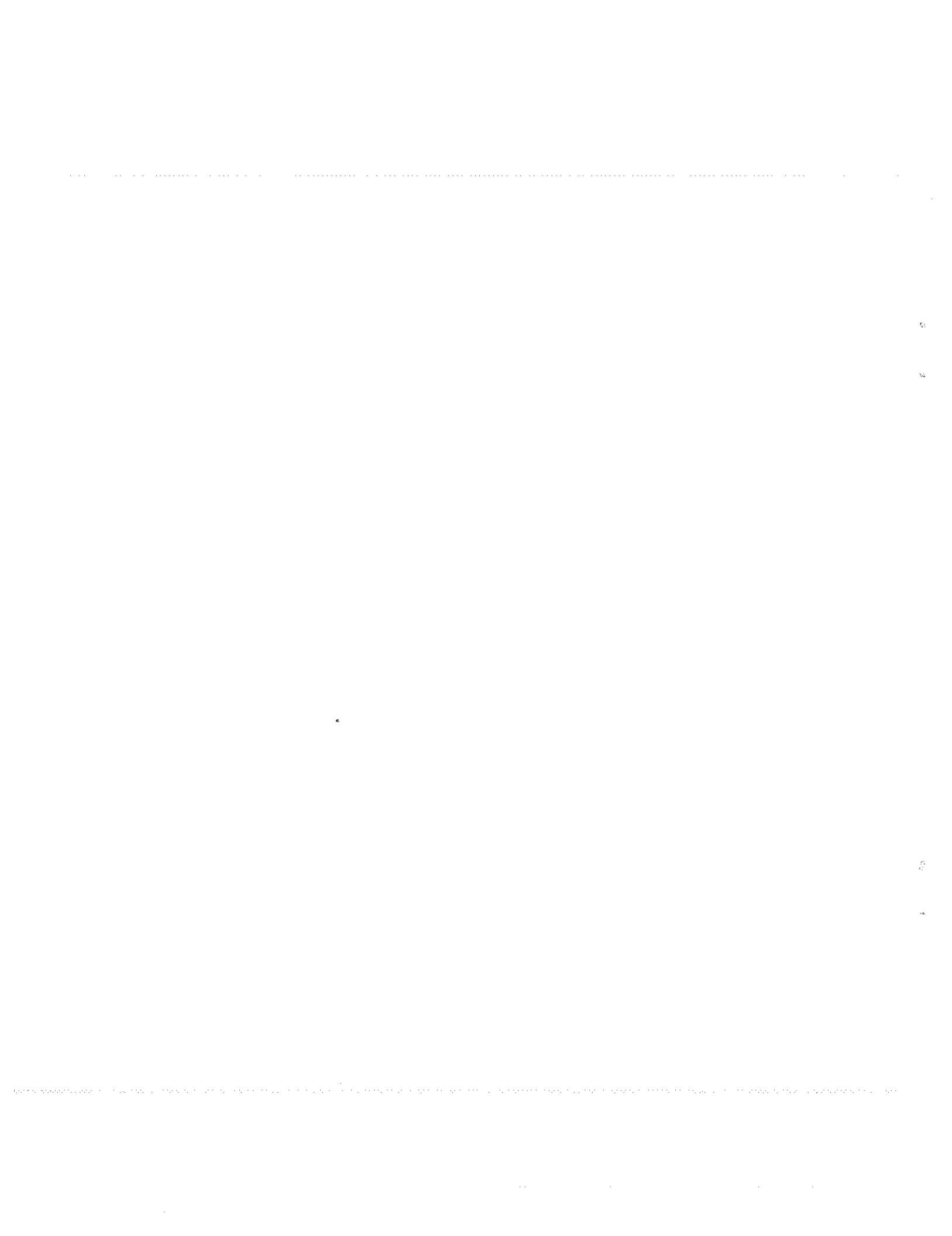
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## ABSTRACT

This report covers work done under NASA Grant NGR 09-015-002 Supplement No. 57. The transfer function of the retroreflector array carried by the Geos 3 satellite has been computed at three wavelength: 5300, 6943, and 106000 Å. The range correction is given for extrapolating laser range measurements to the center of gravity of the satellite. The reflectivity of the array has been computed for estimating laser-echo signal strengths.

OPTICAL AND INFRARED TRANSFER FUNCTION  
OF THE GEOS 3 RETROREFLECTOR ARRAY

Technical Report  
RTOP 161-05-02

1. INTRODUCTION

This is the fourth in a series of reports giving transfer functions for satellites with retroreflector arrays (refs. 1, 2, and 3). Some transfer-function analyses were included in ref. 4. In this report, the analysis of Geos 3 (7502701), which was partially presented in ref. 1, is completed. A special analysis has been done for the infrared cube corner designed for use with lasers operating at  $\lambda = 106000 \text{ \AA}$ .

Data on the Geos 3 retroreflector array were obtained from the Applied Physics Laboratory of Johns Hopkins University and from Goddard Space Flight Center.

## 2. CUBE-CORNER SPECIFICATIONS

The cube corners on Geos 3 have hexagonal entrance faces, each with a width of 35 mm across flats. The length from vertex to face is  $35/\sqrt{2} = 24.75$  mm. The optical reflectors are made of fused silica, and the reflecting faces are silver coated. The dihedral angles between the back faces are  $90^\circ + 2'0 \pm 0'5$  in order to compensate for velocity aberration. The infrared cube corner is made of Irtran-2. The reflecting faces are uncoated, and the dihedral angles are not offset from  $90^\circ$ . Diffraction provides the necessary beam spread at a wavelength of 106000 Å.

### 3. GEOMETRY OF THE ARRAY

The optical retroreflector array consists of 264 cube corners mounted on a 45° conic frustum, as shown in Figure 1. The infrared cube corner is mounted on the end of a tube facing the earth. The optical cube corners are arranged in three rows with 88 cube corners in each row; their orientation is shown in Figure 2.

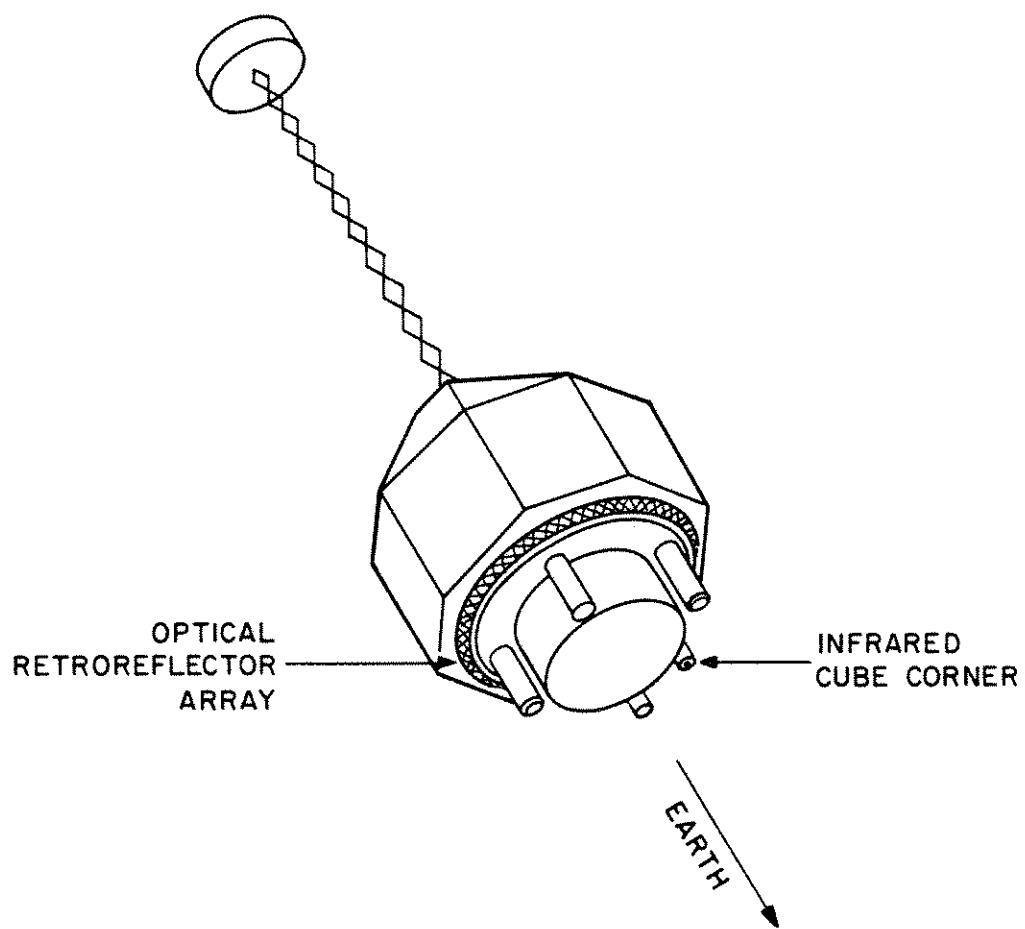


Figure 1. Geos 3 satellite.

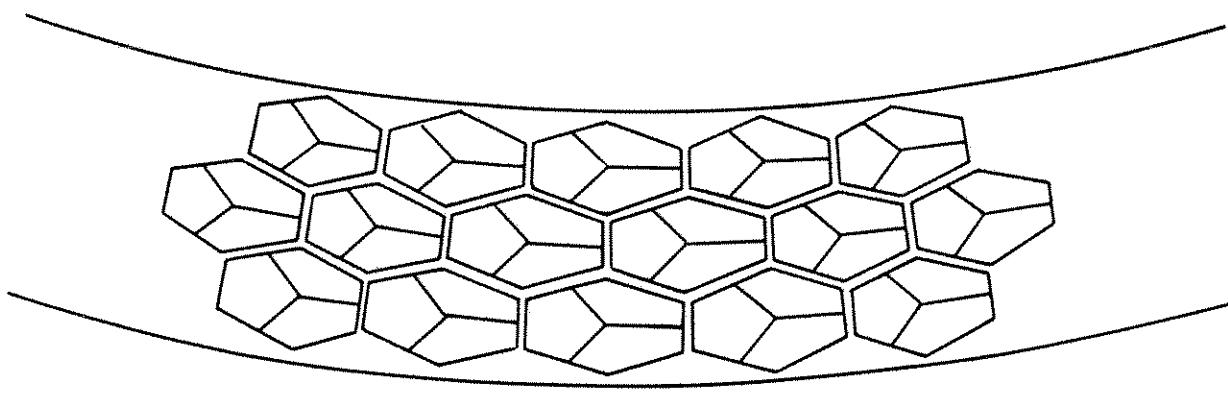


Figure 2. Orientation of optical cube corners.

The coordinate system used to position the cube corners has its origin at the spacecraft orbital center of gravity. The Z axis is parallel to the gravity-gradient boom, with the positive direction away from the spacecraft toward the end mass; the X axis is along the velocity vector, with the positive direction in the direction of flight; and the Y axis is perpendicular to the X and Z axes, with the positive direction chosen to form a right-hand coordinate system. Table 1 lists the radius and Z coordinates of the center of the front face of each row of cube corners.

Table 1. Radius and Z position of each row of optical cube corners.

Row	Radius		Z	
	(inches)	(m)	(inches)	(m)
1	21.390	0.5433	-53.448	-1.3576
2	22.250	0.5652	-52.589	-1.3358
3	23.109	0.5870	-51.730	-1.3139

The spacecraft's center of gravity is not precisely on the symmetry axis of the satellite; the relationship is shown in Figure 3.

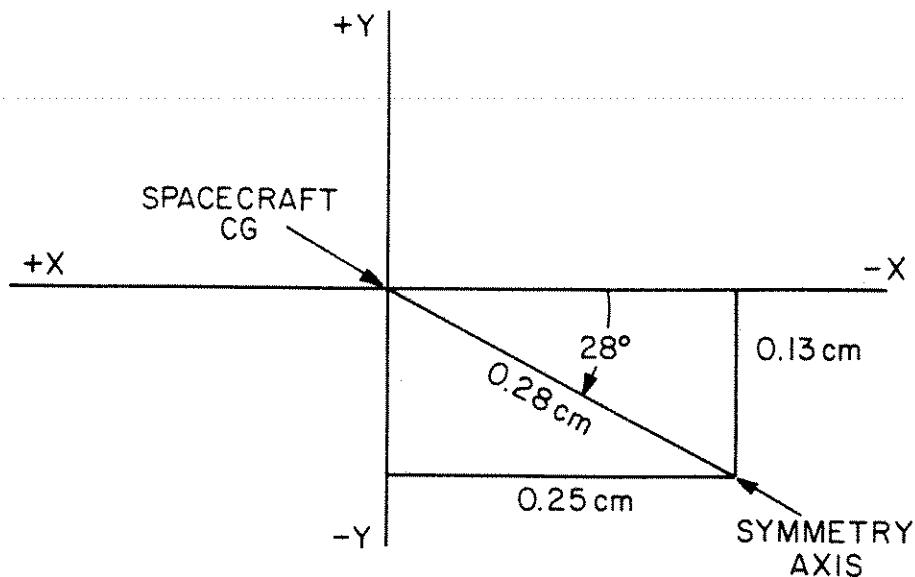


Figure 3. Displacement of the spacecraft center of gravity (CG) from the satellite symmetry axis.

The coordinates of the infrared and the optical cube corners are given in Table 2. The angle  $\theta$ , in degrees, is measured from the center of the array (the symmetry axis of the satellite), as shown in Figure 4. The  $X'$  and  $Y'$  axes are parallel to the  $X$  and  $Y$  axes, with the origin at the symmetry axis. The position and orientation of the infrared cube corner are shown in Figure 5; the  $Z$  coordinate is  $-1.7399$  m. The front face points toward the earth (the direction of the negative  $Z$  axis).

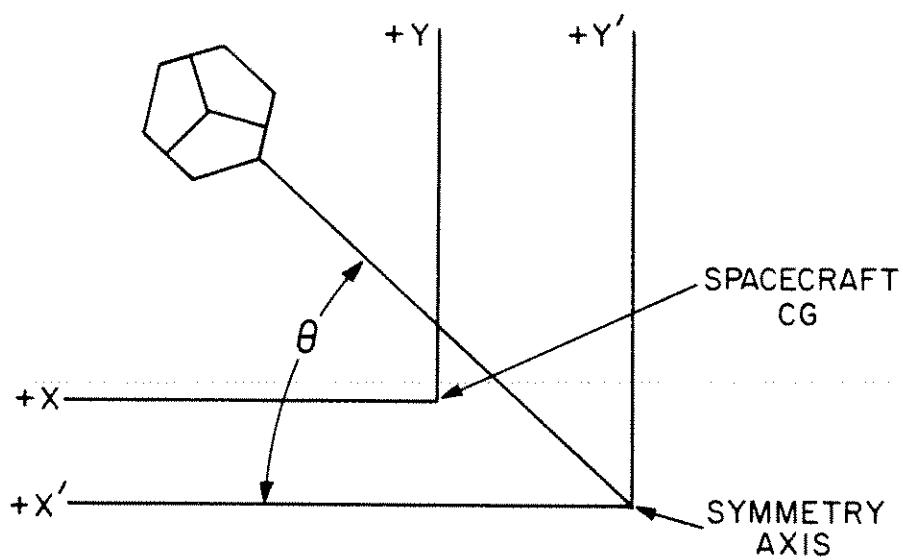


Figure 4. Coordinate system for the optical cube-corner orientation angle  $\theta$ .

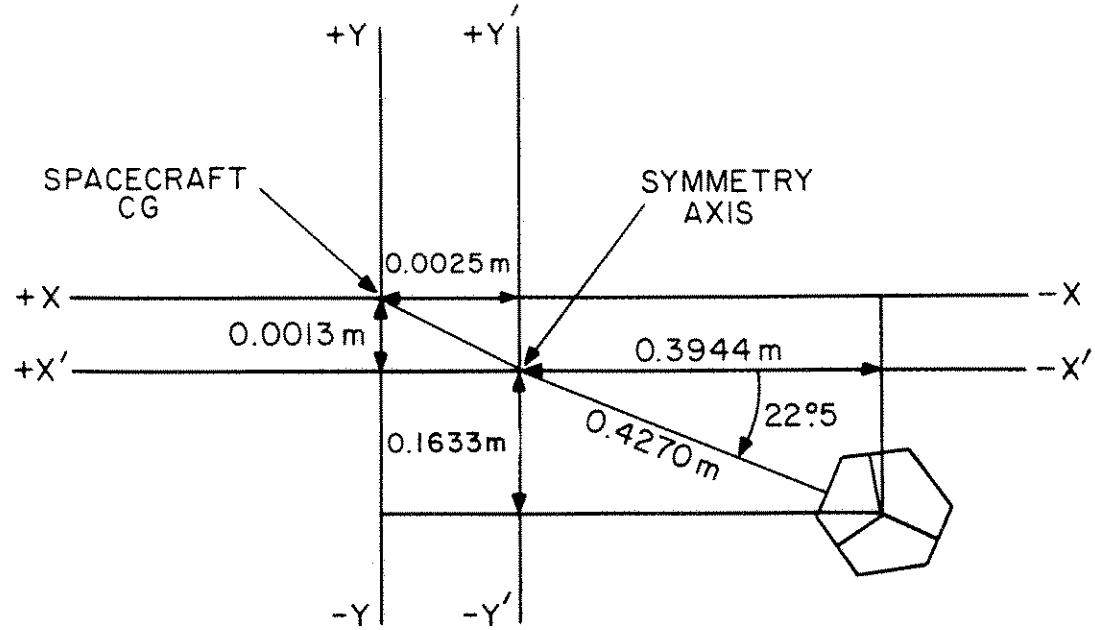


Figure 5. Position and orientation of the infrared cube corner.

Table 2. Cube-corner coordinates.

a: Infrared coordinates (m)

X	Y	Z
-0.3969	-0.1646	-1.7399

b: Optical coordinates (m) and orientation (degrees)

ROW	RETRO	X	Y	Z	THETA	ROW	RETRO	X	Y	Z	THETA
1	1	-.00250	.54201	-1.35758	90.000	1	51	-.22820	-.49551	-1.35758	245.455
1	2	.03626	.54062	-1.35758	85.909	1	52	-.26288	-.47815	-1.35758	241.364
1	3	.07482	.53648	-1.35758	81.618	1	53	-.29623	-.45836	-1.35758	237.273
1	4	.11299	.52959	-1.35758	77.727	1	54	-.32809	-.43624	-1.35758	233.182
1	5	.15057	.52000	-1.35758	73.636	1	55	-.35829	-.41190	-1.35758	229.091
1	6	.18737	.50775	-1.35758	69.545	1	56	-.38668	-.38548	-1.35758	225.000
1	7	.22320	.49291	-1.35758	65.454	1	57	-.41310	-.35709	-1.35758	220.909
1	8	.25788	.47555	-1.35758	61.364	1	58	-.43744	-.32689	-1.35758	216.818
1	9	.29123	.45576	-1.35758	57.273	1	59	-.45956	-.29503	-1.35758	212.727
1	10	.32309	.43364	-1.35758	53.182	1	60	-.47935	-.26168	-1.35758	208.636
1	11	.35329	.40930	-1.35758	49.091	1	61	-.49671	-.22700	-1.35758	204.545
1	12	.38168	.38288	-1.35758	45.000	1	62	-.51155	-.19117	-1.35758	200.455
1	13	.40810	.35449	-1.35758	40.909	1	63	-.52380	-.15437	-1.35758	196.364
1	14	.43244	.32429	-1.35758	36.818	1	64	-.53339	-.11679	-1.35758	192.273
1	15	.45456	.29243	-1.35758	32.727	1	65	-.54028	-.07862	-1.35758	188.182
1	16	.47435	.25908	-1.35758	28.636	1	66	-.54442	-.04006	-1.35758	184.091
1	17	.49171	.22440	-1.35758	24.545	1	67	-.54581	-.00130	-1.35758	180.000
1	18	.50655	.18857	-1.35758	20.454	1	68	-.54442	.03746	-1.35758	175.909
1	19	.51880	.15177	-1.35758	16.363	1	69	-.54028	.07602	-1.35758	171.818
1	20	.52839	.11419	-1.35758	12.273	1	70	-.53339	.11419	-1.35758	167.727
1	21	.53528	.07602	-1.35758	8.182	1	71	-.52380	.15177	-1.35758	163.636
1	22	.53942	.03746	-1.35758	4.091	1	72	-.51155	.18857	-1.35758	159.545
1	23	.54081	-.00130	-1.35758	360.000	1	73	-.49671	.22440	-1.35758	155.454
1	24	.53942	-.04006	-1.35758	355.909	1	74	-.47935	.25908	-1.35758	151.364
1	25	.53528	-.07862	-1.35758	351.818	1	75	-.45956	.29243	-1.35758	147.273
1	26	.52839	-.11679	-1.35758	347.727	1	76	-.43744	.32429	-1.35758	143.182
1	27	.51880	-.15437	-1.35758	343.636	1	77	-.41310	.35449	-1.35758	139.091
1	28	.50655	-.19117	-1.35758	339.545	1	78	-.38668	.38288	-1.35758	135.000
1	29	.49171	-.22700	-1.35758	335.454	1	79	-.35829	.40930	-1.35758	130.909
1	30	.47435	-.26168	-1.35758	331.363	1	80	-.32809	.43364	-1.35758	126.818
1	31	.45456	-.29503	-1.35758	327.273	1	81	-.29623	.45576	-1.35758	122.727
1	32	.43244	-.32689	-1.35758	323.182	1	82	-.26288	.47555	-1.35758	118.636
1	33	.40810	-.35709	-1.35758	319.091	1	83	-.22820	.49291	-1.35758	114.545
1	34	.38168	-.38548	-1.35758	315.000	1	84	-.19237	.50775	-1.35758	110.454
1	35	.35329	-.41190	-1.35758	310.909	1	85	-.15557	.52000	-1.35758	106.363
1	36	.32309	-.43624	-1.35758	306.818	1	86	-.11799	.52959	-1.35758	102.272
1	37	.29123	-.45836	-1.35758	302.728	1	87	-.07982	.53648	-1.35758	98.182
1	38	.25788	-.47815	-1.35758	298.637	1	88	-.04126	.54062	-1.35758	94.091
1	39	.22320	-.49551	-1.35758	294.546	2	1	.01767	.56349	-1.33576	87.955
1	40	.18737	-.51035	-1.35758	290.455	2	2	.05791	.56061	-1.33576	83.864
1	41	.15057	-.52260	-1.35758	286.364	2	3	.09784	.55487	-1.33576	79.773
1	42	.11299	-.53219	-1.35758	282.273	2	4	.13727	.54629	-1.33576	75.682
1	43	.07482	-.53908	-1.35758	278.182	2	5	.17597	.53493	-1.33576	71.591
1	44	.03626	-.54322	-1.35758	274.091	2	6	.21377	.52083	-1.33576	67.500
1	45	-.00250	-.54461	-1.35758	270.000	2	7	.25047	.50407	-1.33576	63.409
1	46	-.04126	-.54322	-1.35758	265.909	2	8	.28588	.48474	-1.33576	59.318
1	47	-.07982	-.53908	-1.35758	261.818	2	9	.31982	.46293	-1.33576	55.227
1	48	-.11799	-.53219	-1.35758	257.727	2	10	.35211	.43875	-1.33576	51.136
1	49	-.15557	-.52260	-1.35758	253.636	2	11	.38260	.41233	-1.33576	47.045
1	50	-.19237	-.51035	-1.35758	249.546	2	12	.41113	.38380	-1.33576	42.954

Table 2. (Cont.)

ROW	RETRO	X	Y	Z	THETA	ROW	RETRO	X	Y	Z	THETA
2	13	.43755	.35331	-1.33576	38.864	2	63	-.55009	-.14107	-1.33576	194.318
2	14	.46173	.32102	-1.33576	34.773	2	64	-.55867	-.10164	-1.33576	190.227
2	15	.48354	.28708	-1.33576	30.682	2	65	-.56441	-.06171	-1.33576	186.136
2	16	.50287	.25167	-1.33576	26.591	2	66	-.56729	-.02147	-1.33576	182.045
2	17	.51963	.21497	-1.33576	22.500	2	67	-.56729	.01887	-1.33576	177.954
2	18	.53373	.17717	-1.33576	18.409	2	68	-.56441	.05911	-1.33576	173.864
2	19	.54509	.13847	-1.33576	14.318	2	69	-.55867	.09904	-1.33576	169.773
2	20	.55367	.09904	-1.33576	10.227	2	70	-.55009	.13847	-1.33576	165.682
2	21	.55941	.05911	-1.33576	6.136	2	71	-.53873	.17717	-1.33576	161.591
2	22	.56229	.01887	-1.33576	2.045	2	72	-.52463	.21497	-1.33576	157.500
2	23	.56229	-.02147	-1.33576	357.954	2	73	-.50787	.25167	-1.33576	153.409
2	24	.55941	-.06171	-1.33576	353.863	2	74	-.48854	.28708	-1.33576	149.318
2	25	.55367	-.10164	-1.33576	349.772	2	75	-.46673	.32102	-1.33576	145.227
2	26	.54509	-.14107	-1.33576	345.682	2	76	-.44255	.35331	-1.33576	141.136
2	27	.53373	-.17977	-1.33576	341.591	2	77	-.41613	.38380	-1.33576	137.045
2	28	.51963	-.21757	-1.33576	337.500	2	78	-.38760	.41233	-1.33576	132.954
2	29	.50287	-.25427	-1.33576	333.409	2	79	-.35711	.43875	-1.33576	128.863
2	30	.48354	-.28968	-1.33576	329.318	2	80	-.32482	.46293	-1.33576	124.773
2	31	.46173	-.32362	-1.33576	325.228	2	81	-.29088	.48474	-1.33576	120.682
2	32	.43755	-.35591	-1.33576	321.137	2	82	-.25547	.50407	-1.33576	116.591
2	33	.41113	-.38640	-1.33576	317.046	2	83	-.21877	.52083	-1.33576	112.500
2	34	.38260	-.41493	-1.33576	312.955	2	84	-.18097	.53493	-1.33576	108.409
2	35	.35211	-.44135	-1.33576	308.864	2	85	-.14227	.54629	-1.33576	104.318
2	36	.31982	-.46553	-1.33576	304.773	2	86	-.10284	.55487	-1.33576	100.227
2	37	.28588	-.48734	-1.33576	300.682	2	87	-.06291	.56061	-1.33576	96.136
2	38	.25047	-.50667	-1.33576	296.591	2	88	-.02267	.56349	-1.33576	92.045
2	39	.21377	-.52343	-1.33576	292.500	3	1	-.00250	.58567	-1.31394	90.000
2	40	.17597	-.53753	-1.33576	288.409	3	2	.03937	.58417	-1.31394	85.909
2	41	.13727	-.54889	-1.33576	284.318	3	3	.08103	.57969	-1.31394	81.818
2	42	.09784	-.55747	-1.33576	280.227	3	4	.12227	.57225	-1.31394	77.727
2	43	.05791	-.56321	-1.33576	276.137	3	5	.16287	.56189	-1.31394	73.636
2	44	.01767	-.56609	-1.33576	272.046	3	6	.20262	.54866	-1.31394	69.545
2	45	-.02267	-.56609	-1.33576	267.955	3	7	.24134	.53263	-1.31394	65.454
2	46	-.06291	-.56321	-1.33576	263.864	3	8	.27880	.51387	-1.31394	61.364
2	47	-.10284	-.55747	-1.33576	259.773	3	9	.31484	.49249	-1.31394	57.273
2	48	-.14227	-.54889	-1.33576	255.682	3	10	.34926	.46859	-1.31394	53.182
2	49	-.18097	-.53753	-1.33576	251.591	3	11	.38188	.44230	-1.31394	49.091
2	50	-.21877	-.52343	-1.33576	247.500	3	12	.41255	.41375	-1.31394	45.000
2	51	-.25547	-.50667	-1.33576	243.409	3	13	.44110	.38308	-1.31394	40.909
2	52	-.29088	-.48734	-1.33576	239.318	3	14	.46739	.35046	-1.31394	36.818
2	53	-.32482	-.46553	-1.33576	235.227	3	15	.49129	.31604	-1.31394	32.727
2	54	-.35711	-.44135	-1.33576	231.136	3	16	.51267	.28000	-1.31394	28.636
2	55	-.38760	-.41493	-1.33576	227.046	3	17	.53143	.24254	-1.31394	24.545
2	56	-.41613	-.38640	-1.33576	222.955	3	18	.54746	.20382	-1.31394	20.454
2	57	-.44255	-.35591	-1.33576	218.864	3	19	.56069	.16407	-1.31394	16.363
2	58	-.46673	-.32362	-1.33576	214.773	3	20	.57105	.12347	-1.31394	12.273
2	59	-.48854	-.28968	-1.33576	210.682	3	21	.57849	.08223	-1.31394	8.182
2	60	-.50787	-.25427	-1.33576	206.591	3	22	.58297	.04057	-1.31394	4.091
2	61	-.52463	-.21757	-1.33576	202.500	3	23	.58447	-.00130	-1.31394	360.000
2	62	-.53873	-.17977	-1.33576	198.409	3	24	.58297	-.04317	-1.31394	355.909

Table 2. (Cont.)

ROW	RETRO	X	Y	Z	THETA	ROW	RETRO	X	Y	Z	THETA
3	25	.57849	-.08483	-1.31394	351.618	3	75	-.49629	.31604	-1.31394	147.273
3	26	.57105	-.12607	-1.31394	347.727	3	76	-.47239	.35046	-1.31394	143.182
3	27	.56069	-.16667	-1.31394	343.636	3	77	-.44610	.38308	-1.31394	139.091
3	28	.54746	-.20642	-1.31394	339.545	3	78	-.41755	.41375	-1.31394	135.000
3	29	.53143	-.24514	-1.31394	335.454	3	79	-.38688	.44230	-1.31394	130.909
3	30	.51267	-.28260	-1.31394	331.363	3	80	-.35426	.46859	-1.31394	126.818
3	31	.49129	-.31864	-1.31394	327.273	3	81	-.31984	.49249	-1.31394	122.727
3	32	.46739	-.35306	-1.31394	323.182	3	82	-.28380	.51387	-1.31394	118.636
3	33	.44110	-.38568	-1.31394	319.091	3	83	-.24634	.53263	-1.31394	114.545
3	34	.41255	-.41635	-1.31394	315.000	3	84	-.20762	.54866	-1.31394	110.454
3	35	.38188	-.44490	-1.31394	310.909	3	85	-.16787	.56189	-1.31394	106.363
3	36	.34926	-.47119	-1.31394	306.818	3	86	-.12727	.57225	-1.31394	102.272
3	37	.31484	-.49509	-1.31394	302.728	3	87	-.08603	.57969	-1.31394	98.182
3	38	.27880	-.51647	-1.31394	298.637	3	88	-.04437	.58417	-1.31394	94.091
3	39	.24134	-.53523	-1.31394	294.546						
3	40	.20262	-.55126	-1.31394	290.455						
3	41	.16287	-.56449	-1.31394	286.364						
3	42	.12227	-.57485	-1.31394	282.273						
3	43	.08103	-.58229	-1.31394	278.182						
3	44	.03937	-.58677	-1.31394	274.091						
3	45	-.00250	-.58827	-1.31394	270.000						
3	46	-.04437	-.58677	-1.31394	265.909						
3	47	-.08603	-.58229	-1.31394	261.818						
3	48	-.12727	-.57485	-1.31394	257.727						
3	49	-.16787	-.56449	-1.31394	253.636						
3	50	-.20762	-.55126	-1.31394	249.546						
3	51	-.24634	-.53523	-1.31394	245.455						
3	52	-.28380	-.51647	-1.31394	241.364						
3	53	-.31484	-.49509	-1.31394	237.273						
3	54	-.35426	-.47119	-1.31394	233.182						
3	55	-.38688	-.44490	-1.31394	229.091						
3	56	-.41755	-.41635	-1.31394	225.000						
3	57	-.44610	-.38568	-1.31394	220.909						
3	58	-.47239	-.35306	-1.31394	216.818						
3	59	-.49629	-.31864	-1.31394	212.727						
3	60	-.51767	-.28260	-1.31394	208.636						
3	61	-.53643	-.24514	-1.31394	204.545						
3	62	-.55246	-.20642	-1.31394	200.455						
3	63	-.56569	-.16667	-1.31394	196.364						
3	64	-.57605	-.12607	-1.31394	192.273						
3	65	-.58349	-.08483	-1.31394	188.182						
3	66	-.58797	-.04317	-1.31394	184.091						
3	67	-.58947	-.00130	-1.31394	180.000						
3	68	-.58797	.04057	-1.31394	175.909						
3	69	-.58349	.08223	-1.31394	171.818						
3	70	-.57605	.12347	-1.31394	167.727						
3	71	-.56569	.16407	-1.31394	163.636						
3	72	-.55246	.20382	-1.31394	159.545						
3	73	-.53643	.24254	-1.31394	155.454						
3	74	-.51767	.28000	-1.31394	151.364						

#### 4. METHOD OF COMPUTING THE TRANSFER FUNCTION

In computing the reflectivity of the Geos 3 retroreflector array, the cube corners have been modeled as isothermal, geometrically perfect reflectors (except for the dihedral-angle offset) with perfect-metal reflecting coatings on the back faces. The primary effect of real metal faces is a decrease in the intensity of the return signal because of the triple metallic reflection. This loss should be added to the constant  $\eta$  of the next section, along with reflection losses at the front face on entering and leaving the cube corners.

Computation of the range correction includes a correction for the optical path length of the ray within the cube corner. The range correction is the difference between the centroid of the actual return signal and the centroid of the return signal that would be received from a point reflector at the center of gravity of the satellite. The correction listed is the one-way correction.

The reflectivities and range corrections presented in all the tables are for the incoherent case; that is, the intensities of the reflections are added without taking into account coherent interference among the reflected signals from the individual cube corners.

The variation of the range correction due to optical coherence has been derived by statistical analysis of a set of coherent returns, which was constructed by assigning random phases to the reflection from each cube corner by means of a pseudo random-number generator. Since the computer time required to compute a coherent return increases as the square of the number of cube corners, the calculations were done with a reduced array obtained by selecting every Nth reflector in each row of cube corners, where N is 2, 4, or 8. Reduced arrays have also been used in diffraction calculations. Except when the calculations have been performed for specific values of velocity aberration, the curves in Figure 7 (Section 6), giving the average reflectivity of the cube corners between velocity aberrations of 25 and 50  $\mu$ rad, have been used to

compute the strength of the reflection from each cube corner. As the curves for 5300 Å and 6943 Å are almost the same, the one for 5300 Å is used unless runs have been made for both wavelengths.

Since the array consists of circular rings of cube corners, the reflectivity is independent of azimuth. The slight offset of the center of gravity from the symmetry axis causes a slight variation of the range correction with azimuth, but the effect on the range is zero when averaged over all azimuths. All the computer runs have been done at an azimuth  $90^\circ$  away from the offset, so there is no effect on the range correction.

## 5. SIGNAL-STRENGTH COMPUTATION

The data contained in the tables presented later can be used to estimate signal strengths for laser ranging by use of the following equation:

$$N = \frac{E}{h\nu} G_T A_S G_S A_R \frac{T^2}{R^4} \eta ,$$

where

$N$  = number of photoelectrons,

$E$  = transmitted energy,

$h$  = Planck's constant,

$\nu$  = frequency of laser light,

$G_T$  = "gain" of transmitter,

$A_S$  = active reflecting area of satellite,

$G_S$  = "gain" of satellite array,

$A_R$  = area of receiving telescope,

$T$  = atmospheric-transmission factor,

$R$  = range from station to satellite,

$\eta$  = constant, which includes the quantum efficiency of the photomultiplier and the optical transmission factors of the transmitter, the satellite, and the receiver.

If the transmitted beam is a uniform spot of solid angle  $\Omega_T$ , the "gain" function of the transmitter is

$$G_T = \frac{1}{\Omega_T} .$$

The gain functions in this equation do not contain the factor of  $4\pi$  used in the standard definition of gain. Those given in later sections can be converted to the standard definition by multiplying by  $4\pi$ . The signal-strength equation above can be converted to the standard definition of gain by adding the factor  $1/(4\pi)^2$ .

## 6. OPTICAL CUBE-CORNER REFLECTIVITY

The reflectivity of the Geos 3 optical cube corners is given below as a function of incidence angle. The angle  $\phi$  is measured from the normal to the front face, and the angle  $\theta$  is the angle to the projection of the incident beam onto the front face; both these angles are shown in Figure 6. In each graph, the upper curve is the total reflectivity and is proportional to the active reflecting area; the lower curve is the average reflectivity in the annulus between 25 and 50  $\mu\text{rad}$  from the center of the reflected beam in the far field, which is approximately that region of the far field observed during laser ranging because of velocity aberration. The curves do not include reflection losses, and all curves are normalized to unity at normal incidence. The active reflecting area at normal incidence is

$$\frac{\sqrt{3}}{2} W^2 = \frac{\sqrt{3}}{2} (3.5 \text{ cm})^2 = 10.6088 \text{ cm}^2$$

for a hexagonal cube corner whose width  $W = 3.5 \text{ cm}$  across flats. If the cube corners had perfect-metal reflecting faces and no dihedral-angle offset, the gain at the center of the far-field pattern would be  $G = A/\lambda^2$ , where  $A$  is the active reflecting area,  $\lambda$  the wavelength of the incident beam, and  $G$  the gain as defined in Section 5. (The standard expression for gain in this case is  $4\pi A/\lambda^2$ .) For the Geos 3 cube corners, the gain at normal incidence in the 25- to 50- $\mu\text{rad}$  annulus for the 5300 and 6943  $\text{\AA}$  wavelengths is 0.0262 and 0.0394, respectively, times  $A/\lambda^2$ .

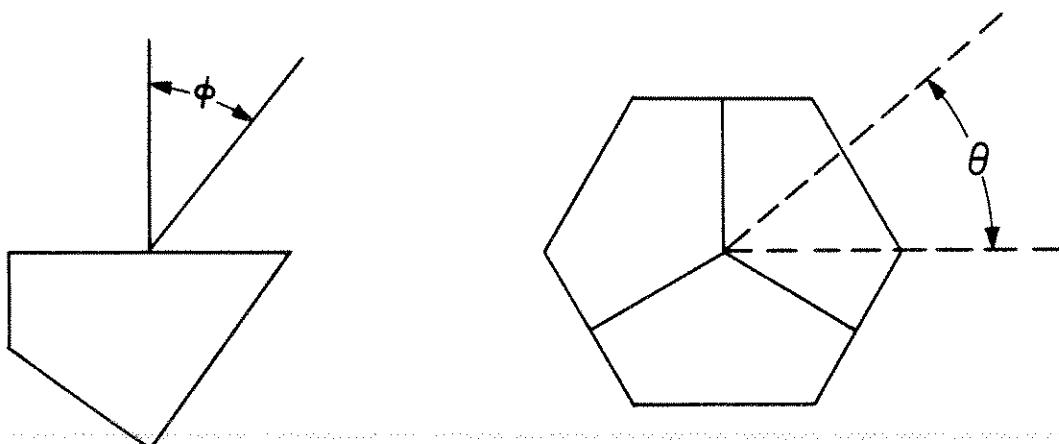


Figure 6. Direction of incident beam.

To convert the normalized reflectivities in the annulus to gain, values from Figure 7 are multiplied by  $G_{5300}$  or  $G_{6943}$ , where

$$G_{5300} = 0.0262 \frac{A}{\lambda_{5300}^2} = 9.895 \times 10^7$$

and

$$G_{6943} = 0.0394 \frac{A}{\lambda_{6943}^2} = 8.671 \times 10^7 .$$

In all the curves of Figure 7, the reflectivity in the annulus falls off more rapidly with incidence angle than does the total reflectivity, because diffraction spreads the beam as the active reflecting area becomes smaller. The curves for the two different wavelengths are fairly similar, but the difference between the total reflectivity and the reflectivity in the annulus is significant. The latter reflectivity does not go as the square of the active reflecting area for two reasons: The reflectivity is not measured at the center of the far-field pattern, and the reflectors have dihedral-angle offsets designed to spread the beam by an amount equal to the velocity aberration. The data used to plot the reflectivity in the annulus are listed in Table 3. The active reflecting area and the reflectivity in the annulus repeat every  $60^\circ$  in  $\theta$ . In addition, the values for  $30^\circ - \theta$  are equal to those for  $30^\circ + \theta$ .

Table 3. Average reflectivity of a Geos 3 optical cube corner in the 25- to 50- $\mu$ rad annulus of the far-field diffraction pattern. The angles  $\theta$  and  $\phi$  are defined in Figure 6.

PHI	THETA 0	THETA 10	THETA 20	THETA 30
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a:  $\lambda = 5300 \text{ \AA}$

0	1.000000	1.000000	1.000000	1.000000
5	.873459	.866570	.861876	.860404
10	.747223	.734170	.725697	.723136
15	.613009	.598221	.590054	.588197
20	.485628	.474333	.470211	.469748
25	.376493	.366436	.359414	.355880
30	.263542	.256402	.247662	.241249
35	.151124	.155796	.162208	.162041
40	.080963	.089195	.110225	.118907
45	.047715	.050723	.064463	.074054
50	.023934	.022251	.023511	.027179
55	.007978	.005420	.002824	.002481
60	.001145	.000191	0.000000	0.000000
65	0.000000	0.000000	0.000000	0.000000

b:  $\lambda = 6943 \text{ \AA}$

0	1.000000	1.000000	1.000000	1.000000
5	.858437	.850265	.846888	.846205
10	.725605	.713353	.709062	.708398
15	.609522	.593175	.585329	.583179
20	.486866	.469136	.458091	.454153
25	.347309	.336414	.331691	.330076
30	.221709	.222177	.232867	.238484
35	.138974	.145139	.166315	.178464
40	.090526	.092933	.110301	.123062
45	.052331	.051291	.056090	.064462
50	.023348	.020770	.017723	.020024
55	.006598	.004545	.001854	.001396
60	.000711	.000076	0.000000	0.000000
65	0.000000	0.000000	0.000000	0.000000

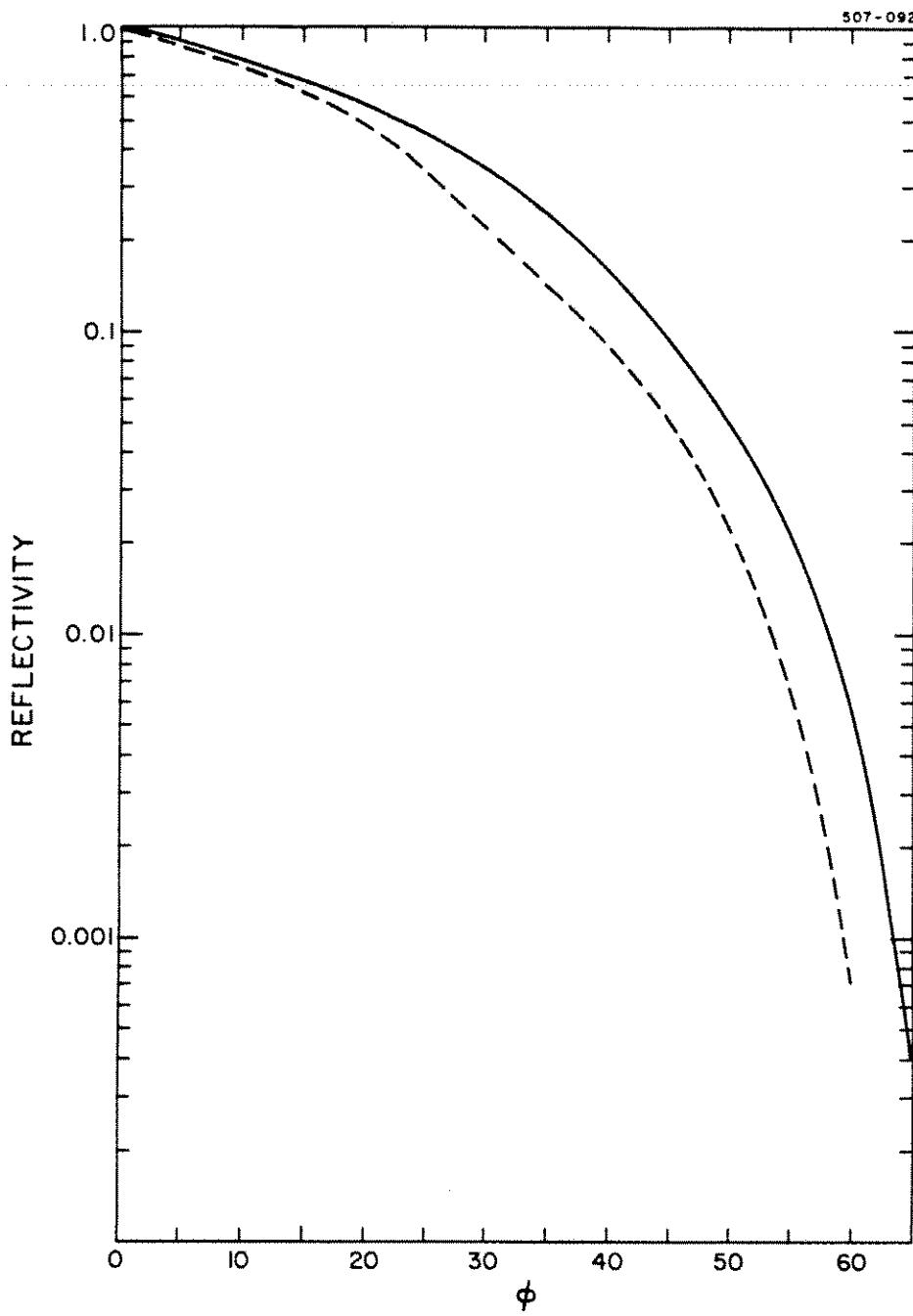


Figure 7. Active reflecting area and average reflectivity in the 25- to 50- $\mu$ rad annulus of the far-field diffraction pattern for a Geos 3 optical cube corner. The incidence angles  $\theta$  and  $\phi$  are defined in Figure 6; the index of refraction  $n$  and the wavelength  $\lambda$  are listed for each set of curves. The solid curve is the active reflecting area (total reflectivity), and the dashed curve, the reflectivity in the 25- to 50- $\mu$ rad annulus. a:  $\theta = 0^\circ$ ,  $n = 1.455$ ,  $\lambda = 6943 \text{ \AA}$ .

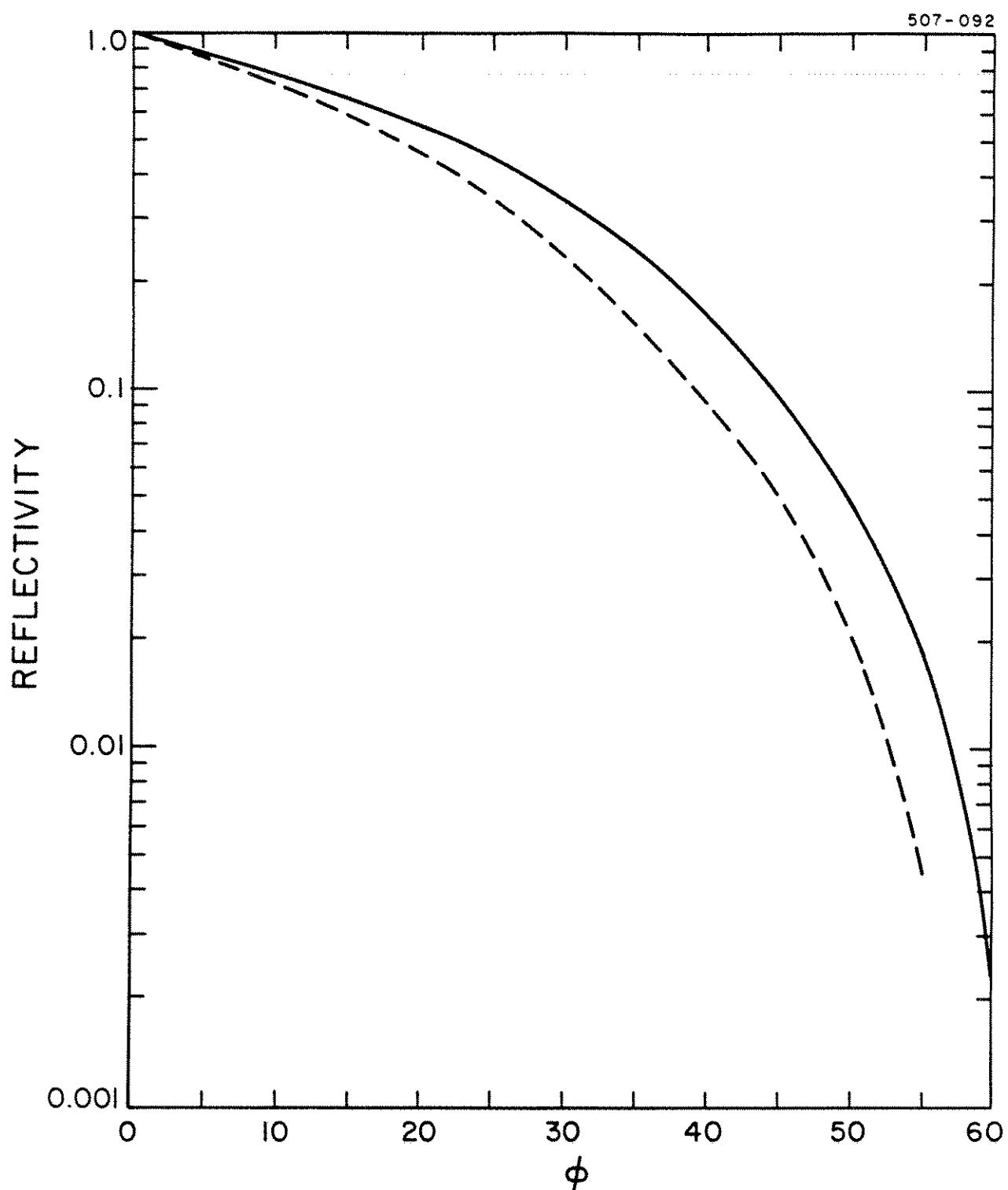


Figure 7b:  $\theta = 10^\circ$ ,  $n = 1.455$ ,  $\lambda = 6943 \text{ \AA}$ .

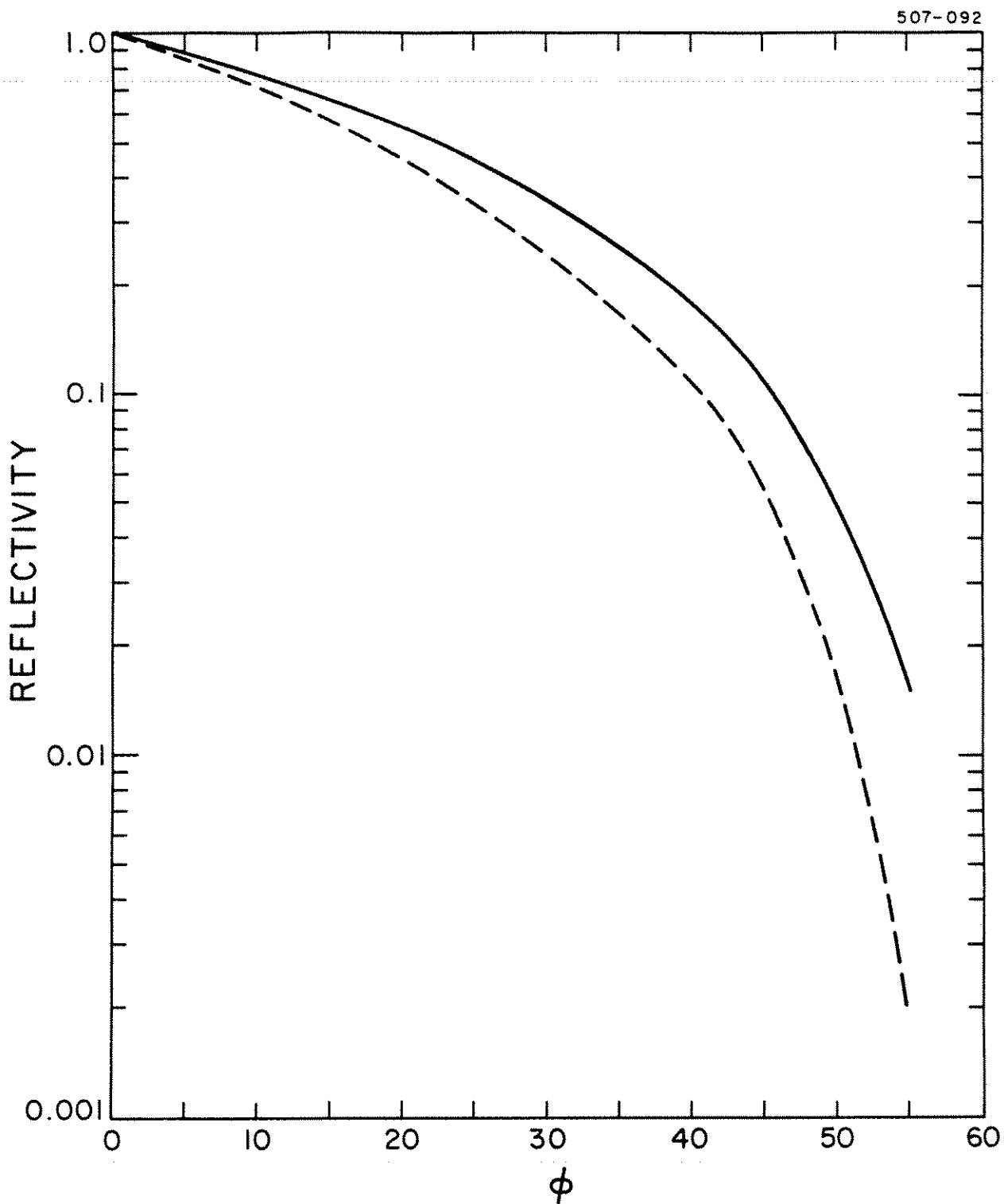


Figure 7c:  $\theta = 20^\circ$ ,  $n = 1.455$ ,  $\lambda = 6943 \text{ \AA}$ .

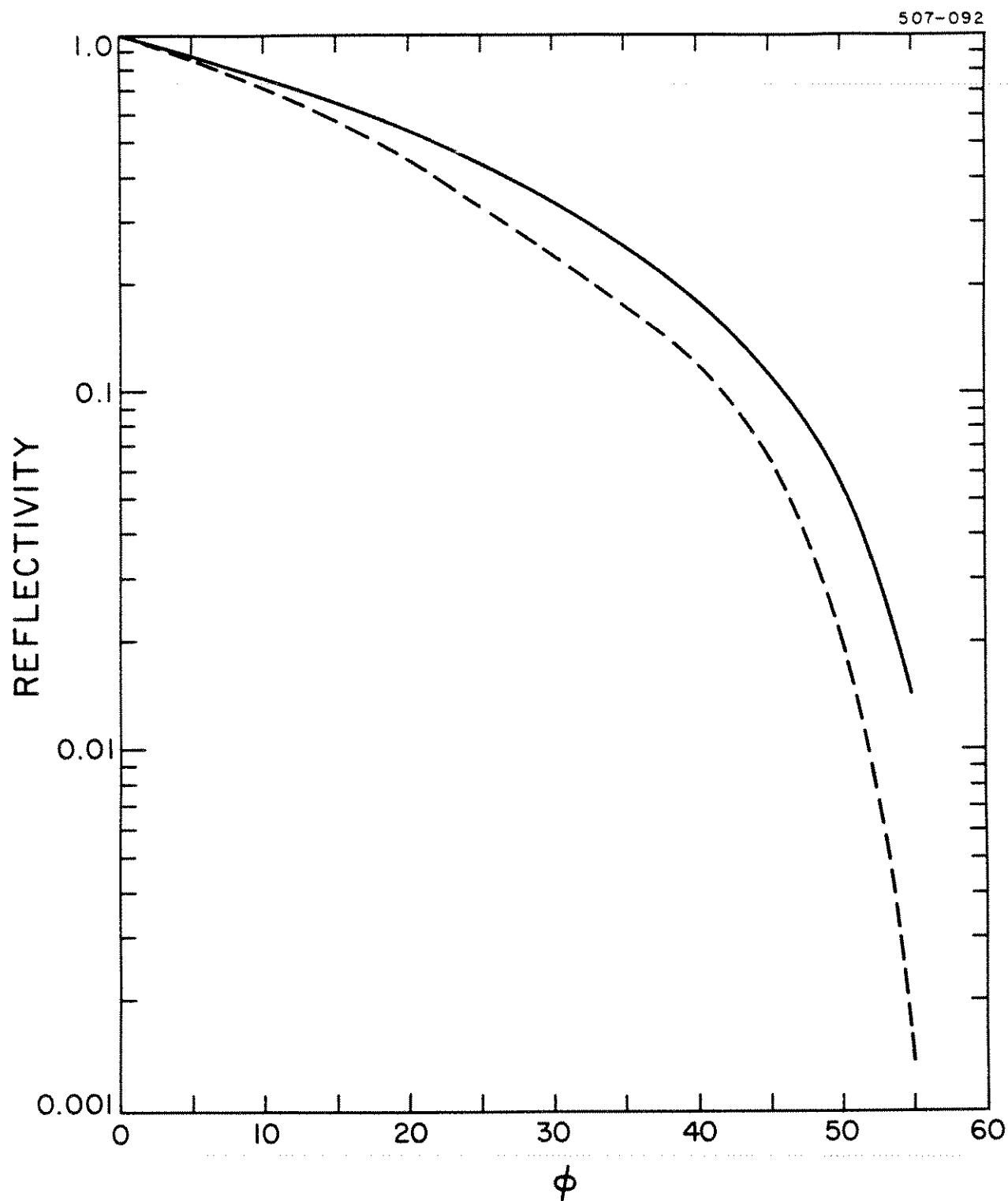


Figure 7d:  $\theta = 30^\circ$ ,  $n = 1.455$ ,  $\lambda = 6943 \text{ \AA}$ .

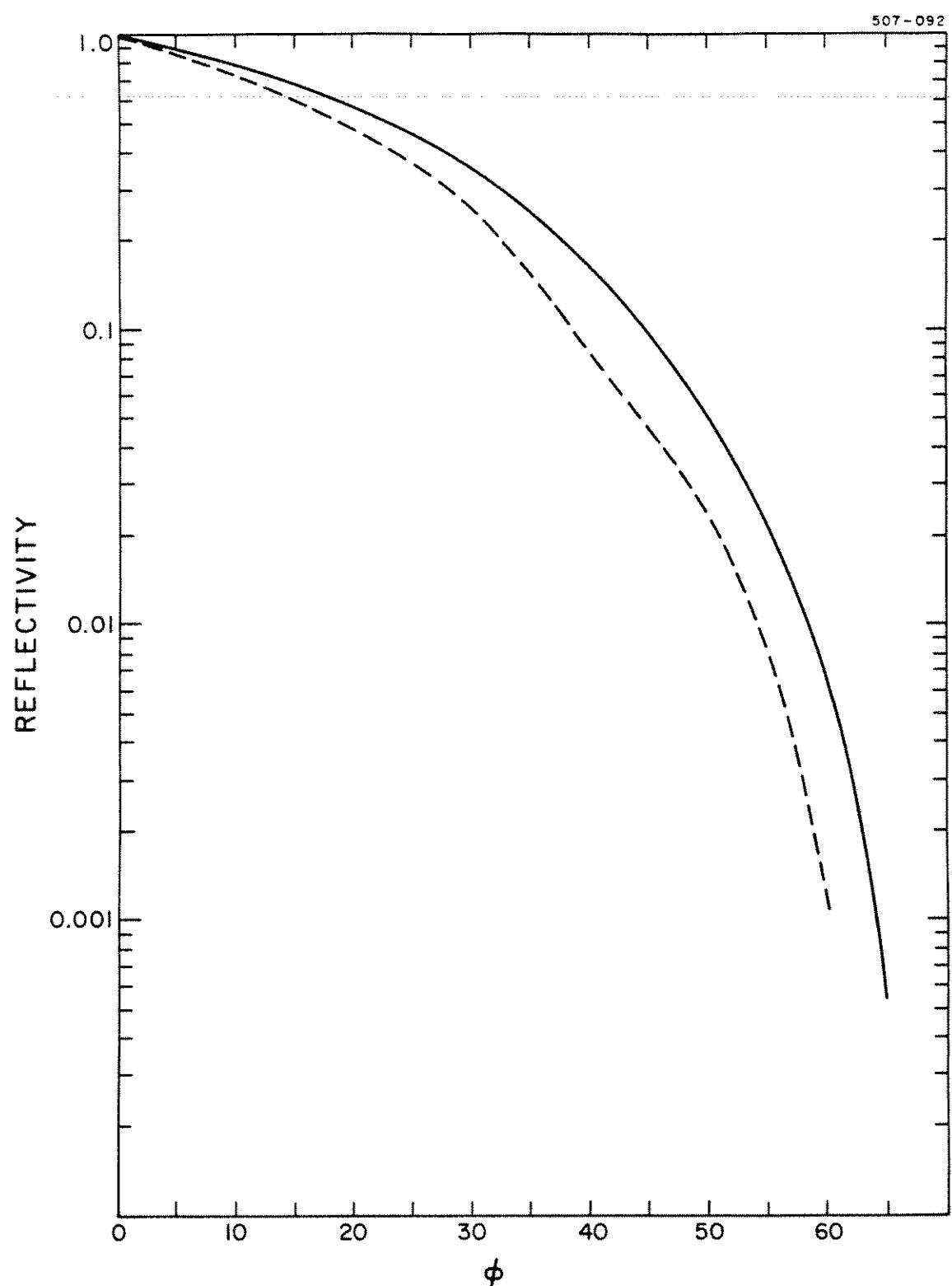


Figure 7e:  $\theta = 0^\circ$ ,  $n = 1.461$ ,  $\lambda = 5300 \text{ \AA}$ .

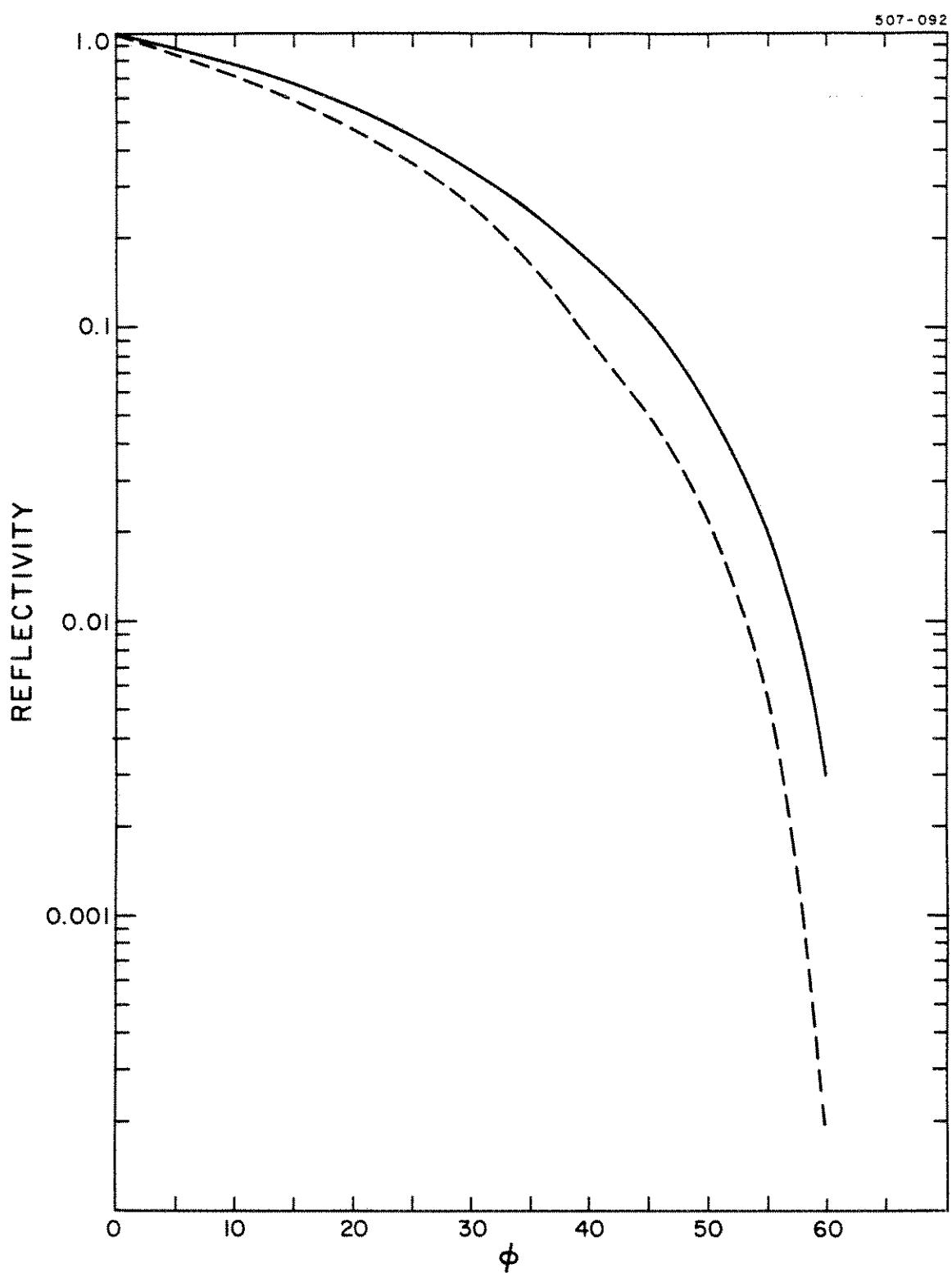


Figure 7f:  $\theta = 10^\circ$ ,  $n = 1.461$ ,  $\lambda = 5300 \text{ \AA}$ .

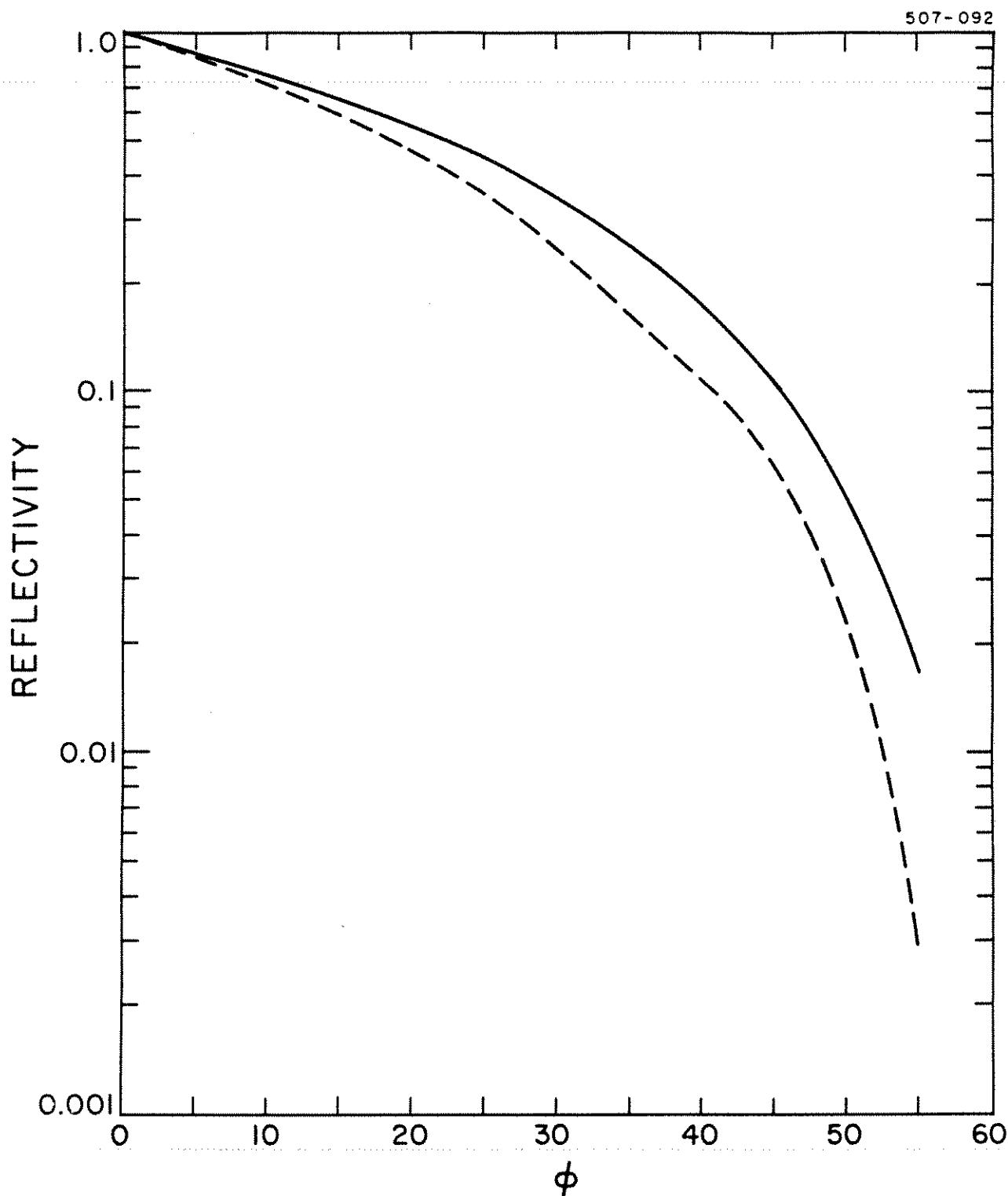


Figure 7g:  $\theta = 20^\circ$ ,  $n = 1.461$ ,  $\lambda = 5300 \text{ \AA}$ .

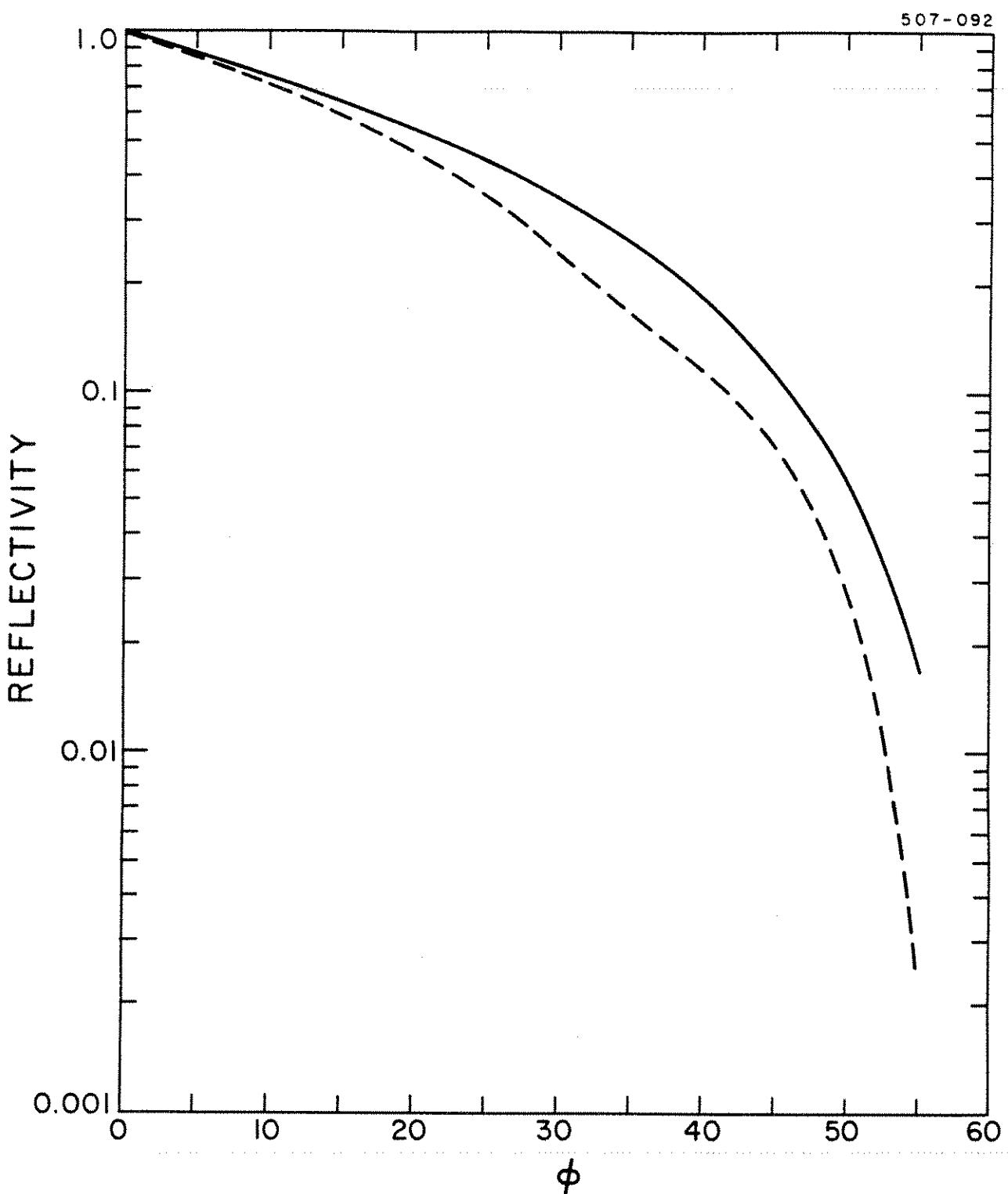


Figure 7h:  $\theta = 30^\circ$ ,  $n = 1.461$ ,  $\lambda = 5300 \text{ \AA}$ .

## 7. ARRAY REFLECTIVITY

This section contains information on the reflectivity of the Geos 3 optical retro-reflector array.

Tables 4 and 5 were computed by using the cube-corner reflectivity curves of Figure 7. Table 4 gives the total reflectivity  $N_T$ , and Table 5, the reflectivity in the annulus  $N_\lambda$  in terms of the equivalent number of cube corners at normal incidence. The area  $A$  of one cube corner at normal incidence is  $10.6088 \text{ cm}^2$ . The total reflected energy, which is proportional to the active reflecting area  $AN_T$ , can be measured only under laboratory conditions. From Table 5, estimates of signal strengths for laser ranging can be made by means of the range equation in Section 5. The array cross section  $A_S G_S$  is given by  $AN_\lambda G_\lambda$ , where  $G_{5300} = 9.895 \times 10^7$  and  $G_{6943} = 8.671 \times 10^7$ . To use the gain-function data of Tables 6 and 7 in the range equation, set the cross section  $A_S G_S$  equal to  $AN_T G$ , taking  $G$  from the appropriate table.

Table 5 shows that the reflectivity in the 25- to 50- $\mu\text{rad}$  annulus is about the same for both wavelengths, but there is a significant difference between the curves of Tables 4 and 5. For example, at  $\phi = 0^\circ$ , the total reflectivity is equivalent to about 25 cube corners; however, the reflectivity in the annulus is equivalent to only 12 or 13 cube corners. The maximum reflectivity of the array occurs between  $40^\circ$  and  $45^\circ$  as a result of the  $45^\circ$  tilt of the cube corners with respect to the symmetry axis. The reflectivity at  $60^\circ$  is large compared to previous Geos arrays, with the result that signal strengths are much stronger under the adverse conditions of long range and low elevations above the horizon. Since the satellite is gravity stabilized, the incidence angle  $\phi$  cannot be more than about  $60^\circ$ .

In the computer-plotted graphs to the right of Tables 4 and 5, the reflectivity increases to the right and the incidence angle  $\phi$  increases down the page.

Table 6 shows how the array gain function varies with velocity aberration. The first column is the magnitude of the velocity aberration in microradians, and the

second is the array gain function in units of  $10^7$ . In the computer-plotted graph, the gain function increases to the right and the velocity aberration, down the page. The gain function is the average value around a circle in the far field with radius equal to the velocity aberration. The second part of each table gives the root-mean-square (rms) variation of the gain around the circle. At  $\phi = 0^\circ$ , the gain has almost perfect circular symmetry, as indicated by the fact that the rms variation is nearly zero. The curves for larger incidence angles, such as  $\phi = 45^\circ$ , show the effect of the dihedral-angle offset in peaking the intensity in the 25- to 50- $\mu\text{rad}$  annulus.

Some of the gain-function matrices from which the data of Table 6 were computed are given in Table 7. Only the right half of the matrix has been presented, since the diffraction pattern for a cube corner with perfect-metal reflecting faces has the symmetry property  $G(\theta_1, \theta_2) = G(-\theta_1, -\theta_2)$ . The angles  $\theta_1$  and  $\theta_2$ , in microradians, are defined in Figure 8. The angle  $\theta_2$  is in the direction of decreasing  $\phi$  in the plane containing the  $-Z$  axis and the direction toward the illuminating laser (the vector  $\hat{V}$ ). The angle  $\theta_1$  is normal to the plane in the direction of  $-\hat{Z} \times \hat{V}$ .

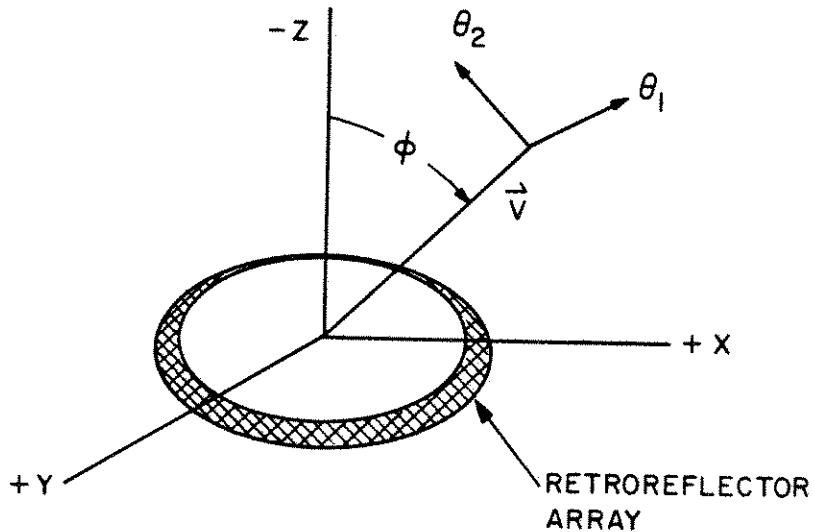


Figure 8. Diffraction-pattern coordinate system.

Figure 9 (p. 42) consists of contour plots of the gain-function matrices given in Table 7. Circles have been drawn with radii of 25 and 50  $\mu$ rad to mark the minimum and maximum values of velocity aberration. The contour levels plotted are 8, 4, 2, 1, and  $0.5 \times 10^7$ . The positions of peaks in the pattern are indicated by asterisks. The contours for  $\phi = 0^\circ$  are circles because of the symmetry of the array, while those for larger values of  $\phi$  show an unexpected asymmetry. We had expected to find  $G(\theta_1, \theta_2) = G(-\theta_1, \theta_2)$  because the distribution of cube corners in the array is symmetrical in this direction (see Figure 8). The asymmetry is the result of the orientation of the cube corners: From Figure 2 we see that the orientation of a cube corner on the left is not symmetrical with respect to one on the right.

If the cube corners were oriented as shown in Figure 10, the far-field pattern would be symmetrical from left to right. [Note: The packing is obviously not so efficient in Figure 10 as it is in Figure 2.] If the dihedral-angle offset were not present, the asymmetry would disappear, since the direction of the exiting wavefront for each of the six sectors of the cube corner would be the same regardless of the order of the reflections at the back faces. The array transfer function would not be improved by making it symmetrical, however, because the variations in intensity and range correction between different points in the far field would still be about the same.

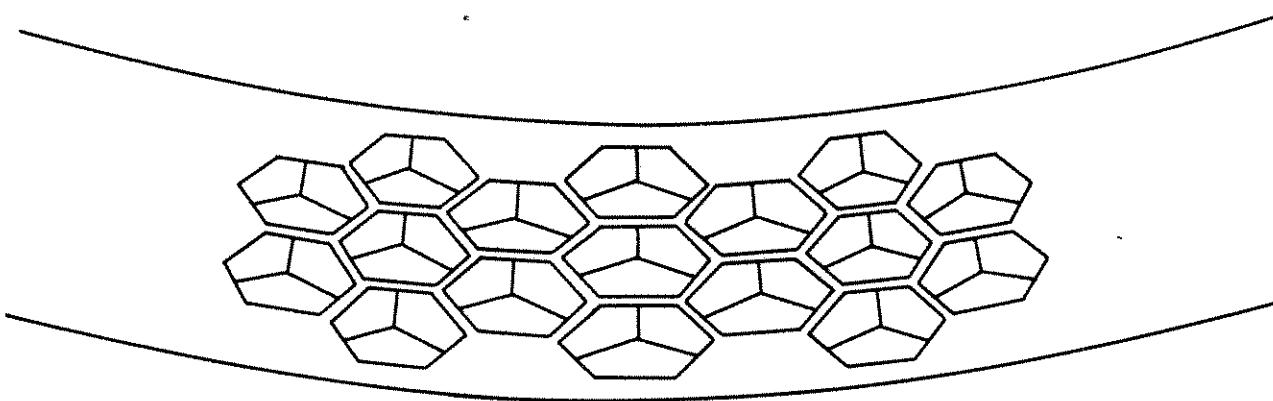


Figure 10. Alternate method of cube-corner orientation.

Table 4. Total reflectivity (active reflecting area) of the Geos 3 optical retroreflector array vs. incidence angle.

PHI (DEG)	REFLECTIVITY	PHI (DEG)	REFLECTIVITY
0.0	25.3219	56.0	39.6922
1.0	25.3645	57.0	38.4430
2.0	25.4922	58.0	37.1668
3.0	25.7048	59.0	35.8654
4.0	26.0019	60.0	34.5506
5.0	26.3832	61.0	33.2210
6.0	26.6480	62.0	31.8783
7.0	27.3957	63.0	30.5294
8.0	28.0253	64.0	29.1755
9.0	28.7359	65.0	27.8229
10.0	29.5265	66.0	26.4738
11.0	30.3774	67.0	25.1459
12.0	31.2534	68.0	23.8541
13.0	32.1389	69.0	22.6005
14.0	33.0266	70.0	21.3793
15.0	33.9106	71.0	20.1916
16.0	34.7862	72.0	19.0404
17.0	35.6489	73.0	17.9232
18.0	36.4986	74.0	16.8379
19.0	37.4016	75.0	15.7857
20.0	38.3168	76.0	14.7653
21.0	39.2199	77.0	13.7737
22.0	40.1024	78.0	12.8108
23.0	40.9548	79.0	11.8781
24.0	41.7718	80.0	10.9755
25.0	42.5542	81.0	10.1027
26.0	43.3003	82.0	9.2628
27.0	44.0151	83.0	8.4550
28.0	44.7099	84.0	7.6798
29.0	45.3828	85.0	6.9379
30.0	46.0394	86.0	6.2295
31.0	46.6773	87.0	5.5555
32.0	47.2979	88.0	4.9163
33.0	47.8972	89.0	4.3120
34.0	48.4759	90.0	3.7425
35.0	49.0348	91.0	3.2075
36.0	49.5727	92.0	2.7069
37.0	50.0898	93.0	2.2424
38.0	50.5691	94.0	1.8300
39.0	50.8707	95.0	1.4719
40.0	51.0306	96.0	1.1618
41.0	51.0704	97.0	0.9051
42.0	50.9790	98.0	0.6922
43.0	50.7805	99.0	0.5190
44.0	50.4567	100.0	0.3835
45.0	50.0118	101.0	0.2789
46.0	49.4659	102.0	0.1972
47.0	48.8188	103.0	0.1329
48.0	48.0613	104.0	0.0867
49.0	47.2324	105.0	0.0555
50.0	46.3289	106.0	0.0327
51.0	45.3640	107.0	0.0178
52.0	44.3277	108.0	0.0079
53.0	43.2273	109.0	0.0028
54.0	42.0866	110.0	0.0006
55.0	40.9030	111.0	0.0001

ONE REFLECTOR AT NORMAL INCIDENCE HAS UNIT REFLECTIVITY

ONE REFLECTOR AT NORMAL INCIDENCE HAS UNIT REFLECTIVITY

Table 5. Average reflectivity of the Geos 3 optical retroreflector array in the 25- to 50- $\mu$ rad annulus of the far-field diffraction pattern. a:  $\lambda = 5300 \text{ \AA}$ .

PHI (DEG)	REFLECTIVITY	PHI (DEG)	REFLECTIVITY
0.0	12.5966	56.0	32.8375
1.0	12.8215	57.0	31.6278
2.0	13.0345	58.0	30.4000
3.0	13.2356	59.0	29.1506
4.0	13.4248	60.0	27.8940
5.0	13.6020	61.0	26.6296
6.0	14.0430	62.0	25.3382
7.0	14.6349	63.0	24.0273
8.0	15.3530	64.0	22.7034
9.0	16.1393	65.0	21.3837
10.0	16.9381	66.0	20.0970
11.0	17.9411	67.0	18.8160
12.0	19.0581	68.0	17.5627
13.0	20.2037	69.0	16.3471
14.0	21.3457	70.0	15.1700
15.0	22.4211	71.0	14.0570
16.0	23.4786	72.0	13.0052
17.0	24.5371	73.0	12.0208
18.0	25.5926	74.0	11.1036
19.0	26.6455	75.0	10.2482
20.0	27.6897	76.0	9.4432
21.0	28.7051	77.0	8.6856
22.0	29.6262	78.0	7.9663
23.0	30.532	79.0	7.2966
24.0	31.4339	80.0	6.6751
25.0	32.3358	81.0	6.1238
26.0	33.2677	82.0	5.5822
27.0	34.2080	83.0	5.0335
28.0	35.0859	84.0	4.496
29.0	35.9273	85.0	3.9920
30.0	36.7416	86.0	3.5535
31.0	37.5435	87.0	3.1232
32.0	38.3311	88.0	2.7066
33.0	39.0926	89.0	2.2935
34.0	39.8445	90.0	1.9339
35.0	40.5836	91.0	1.6116
36.0	41.3034	92.0	1.3360
37.0	41.9966	93.0	1.0539
38.0	42.6427	94.0	8232
39.0	43.1059	95.0	6335
40.0	43.4326	96.0	4192
41.0	43.6205	97.0	3725
42.0	43.6604	98.0	2698
43.0	43.5997	99.0	1865
44.0	43.3630	100.0	1318
45.0	42.9896	101.0	1016
46.0	42.5823	102.0	7229
47.0	41.9602	103.0	467
48.0	41.1219	104.0	239
49.0	40.3021	105.0	96
50.0	39.4056	106.0	077
51.0	38.4444	107.0	057
52.0	37.4072	108.0	037
53.0	36.3102	109.0	017
54.0	35.1854		
55.0	34.0247		

ONE REFLECTOR AT NORMAL INCIDENCE HAS UNIT REFLECTIVITY

ONE REFLECTOR AT NORMAL INCIDENCE HAS UNIT REFLECTIVITY

Table 5b:  $\lambda = 6943 \text{ \AA}$ .

PHI (DEG)	REFLECTIVITY	PHI (DEG)	REFLECTIVITY
0.0	13.8152	56.0	32.0954
1.0	13.9392	57.0	30.8557
2.0	14.0552	58.0	29.5980
3.0	14.1642	59.0	28.2297
4.0	14.2551	60.0	26.8992
5.0	14.3347	61.0	25.4667
6.0	14.4529	62.0	24.0744
7.0	14.5849	63.0	22.6934
8.0	15.2425	64.0	21.3077
9.0	15.7016	65.0	20.0170
10.0	16.1949	66.0	18.7418
11.0	16.9008	67.0	17.0665
12.0	17.405	68.0	16.3334
13.0	18.6615	69.0	15.2342
14.0	19.5677	70.0	14.0833
15.0	20.4991	71.0	13.2635
16.0	21.5005	72.0	12.3609
17.0	22.439	73.0	11.4964
18.0	23.9256	74.0	10.6158
19.0	25.4052	75.0	9.9117
20.0	26.2602	76.0	9.2262
21.0	27.4096	77.0	8.5509
22.0	28.3229	78.0	7.8838
23.0	29.4027	79.0	7.3348
24.0	30.3772	80.0	6.6082
25.0	31.2489	81.0	6.0407
26.0	32.1222	82.0	5.7552
27.0	32.7793	83.0	4.9132
28.0	33.7877	84.0	4.3711
29.0	34.7745	85.0	3.8538
30.0	35.3561	86.0	3.3732
31.0	36.1214	87.0	2.8162
32.0	36.6676	88.0	2.4837
33.0	37.5906	89.0	2.0873
34.0	38.3623	90.0	1.7303
35.0	39.1284	91.0	1.4347
36.0	39.8863	92.0	1.1591
37.0	40.6168	93.0	0.9166
38.0	41.2922	94.0	0.7086
39.0	41.7810	95.0	0.5469
40.0	42.1089	96.0	0.4261
41.0	42.2956	97.0	0.3185
42.0	42.3424	98.0	0.2289
43.0	42.3173	99.0	0.1543
44.0	42.5546	100.0	0.1049
45.0	41.8672	101.0	0.0813
46.0	41.4072	102.0	0.0583
47.0	40.8101	103.0	0.0368
48.0	40.0850	104.0	0.0176
49.0	39.2887	105.0	0.0055
50.0	38.4285	106.0	0.0044
51.0	37.5242	107.0	0.0033
52.0	36.5497	108.0	0.0021
53.0	35.5060	109.0	0.0010
54.0	34.4152		
55.0	33.2708		

ONE REFLECTOR AT NORMAL INCIDENCE HAS UNIT REFLECTIVITY

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Table 6. Gain function vs. velocity aberration for the Geos 3 optical retroreflector array. The average and rms fluctuations are computed around a circle in the far field whose radius is the velocity aberration listed in the first column, in microradians. The gain differs by  $4\pi$  from the standard definition (see Section 5).

a: PHI		DIHEDRAL ANGLE 2.00		WAVELENGTH 5300		b: PHI		DIHEDRAL ANGLE 2.00		WAVELENGTH 5300	
AVERAGE GAIN FUNCTION (1.E+7)				AVERAGE GAIN FUNCTION (1.E+7)				AVERAGE GAIN FUNCTION (1.E+7)			
0	10.94	*	*	*	*	*	*	0	9.93	*	*
5	10.70	*	*	*	*	*	*	5	9.75	*	*
10	10.18	*	*	*	*	*	*	10	9.34	*	*
15	9.43	*	*	*	*	*	*	15	8.75	*	*
20	8.54	*	*	*	*	*	*	20	8.02	*	*
25	7.58	*	*	*	*	*	*	25	7.17	*	*
30	6.56	*	*	*	*	*	*	30	6.25	*	*
35	5.51	*	*	*	*	*	*	35	5.36	*	*
40	4.50	*	*	*	*	*	*	40	4.60	*	*
45	3.61	*	*	*	*	*	*	45	3.99	*	*
50	2.91	*	*	*	*	*	*	50	3.51	*	*
R.M.S. FLUCTUATION											
0	0.00	*	*	*	*	*	*	0	0.00	*	*
5	0.02	*	*	*	*	*	*	5	0.05	*	*
10	0.02	*	*	*	*	*	*	10	0.17	*	*
15	0.01	*	*	*	*	*	*	15	0.31	*	*
20	0.01	*	*	*	*	*	*	20	0.37	*	*
25	0.01	*	*	*	*	*	*	25	0.34	*	*
30	0.01	*	*	*	*	*	*	30	0.24	*	*
35	0.01	*	*	*	*	*	*	35	0.17	*	*
40	0.01	*	*	*	*	*	*	40	0.22	*	*
45	0.01	*	*	*	*	*	*	45	0.28	*	*
50	0.01	*	*	*	*	*	*	50	0.33	*	*
R.M.S. FLUCTUATION											
0	7.71	*	*	*	*	*	*	0	5.60	*	*
5	7.63	*	*	*	*	*	*	5	5.52	*	*
10	7.43	*	*	*	*	*	*	10	5.50	*	*
15	7.14	*	*	*	*	*	*	15	5.67	*	*
20	6.75	*	*	*	*	*	*	20	5.97	*	*
25	6.31	*	*	*	*	*	*	25	6.33	*	*
30	5.96	*	*	*	*	*	*	30	6.70	*	*
35	5.73	*	*	*	*	*	*	35	6.95	*	*
40	5.52	*	*	*	*	*	*	40	6.79	*	*
45	5.16	*	*	*	*	*	*	45	6.12	*	*
50	4.60	*	*	*	*	*	*	50	5.13	*	*
R.M.S. FLUCTUATION											
0	0.00	*	*	*	*	*	*	0	0.00	*	*
5	0.12	*	*	*	*	*	*	5	0.19	*	*
10	0.45	*	*	*	*	*	*	10	0.63	*	*
15	0.72	*	*	*	*	*	*	15	0.79	*	*
20	0.76	*	*	*	*	*	*	20	0.49	*	*
25	0.58	*	*	*	*	*	*	25	0.52	*	*
30	0.42	*	*	*	*	*	*	30	0.90	*	*
35	0.53	*	*	*	*	*	*	35	1.09	*	*
40	0.71	*	*	*	*	*	*	40	1.25	*	*
45	0.84	*	*	*	*	*	*	45	1.31	*	*
50	0.85	*	*	*	*	*	*	50	1.19	*	*

Table 6. (Cont.)

AVERAGE GAIN FUNCTION (1.E+7)				AVERAGE GAIN FUNCTION (1.E+7)				AVERAGE GAIN FUNCTION (1.E+7)						
e:	PHI	20	DIHEDRAL ANGLE 2.00	WAVELENGTH 5300	f:	PHI	25	DIHEDRAL ANGLE 2.00	WAVELENGTH 5300	h:	PHI	35	DIHEDRAL ANGLE 2.00	WAVELENGTH 5300
0	4.68	*	*	*	0	4.60	*	*	*	0	5.49	*	*	*
5	4.34	*	*	*	5	3.84	*	*	*	5	3.97	*	*	*
10	4.17	*	*	*	10	3.34	*	*	*	10	3.73	*	*	*
15	4.83	*	*	*	15	4.28	*	*	*	15	5.55	*	*	*
20	6.09	*	*	*	20	6.18	*	*	*	20	6.66	*	*	*
25	7.23	*	*	*	25	7.63	*	*	*	25	7.58	*	*	*
30	7.83	*	*	*	30	8.12	*	*	*	30	8.90	*	*	*
35	7.84	*	*	*	35	8.02	*	*	*	35	8.03	*	*	*
40	7.31	*	*	*	40	7.61	*	*	*	40	7.61	*	*	*
45	6.42	*	*	*	45	6.92	*	*	*	45	6.92	*	*	*
50	5.44	*	*	*	50	5.98	*	*	*	50	6.58	*	*	*
R.M.S. FLUCTUATION														
0	0.00	*	*	*	0	0.00	*	*	*	0	0.00	*	*	*
5	0.25	*	*	*	5	0.22	*	*	*	5	0.25	*	*	*
10	0.69	*	*	*	10	0.50	*	*	*	10	0.71	*	*	*
15	1.59	*	*	*	15	1.45	*	*	*	15	1.99	*	*	*
20	1.62	*	*	*	20	1.24	*	*	*	20	1.55	*	*	*
25	1.51	*	*	*	25	1.86	*	*	*	25	1.17	*	*	*
30	1.67	*	*	*	30	1.50	*	*	*	30	1.35	*	*	*
35	1.37	*	*	*	35	1.17	*	*	*	35	1.39	*	*	*
40	1.45	*	*	*	40	1.35	*	*	*	40	1.39	*	*	*
45	1.46	*	*	*	45	1.35	*	*	*	45	1.39	*	*	*
50	1.30	*	*	*	50	1.38	*	*	*	50	1.38	*	*	*
R.M.S. FLUCTUATION														
0	5.02	*	*	*	0	5.49	*	*	*	0	0.00	*	*	*
5	3.84	*	*	*	5	3.97	*	*	*	5	0.25	*	*	*
10	2.96	*	*	*	10	2.79	*	*	*	10	0.71	*	*	*
15	3.97	*	*	*	15	3.73	*	*	*	15	1.99	*	*	*
20	6.00	*	*	*	20	5.55	*	*	*	20	1.93	*	*	*
25	7.30	*	*	*	25	6.66	*	*	*	25	1.58	*	*	*
30	7.81	*	*	*	30	7.58	*	*	*	30	1.42	*	*	*
35	6.20	*	*	*	35	8.70	*	*	*	35	1.42	*	*	*
40	8.32	*	*	*	40	8.99	*	*	*	40	1.42	*	*	*
45	7.66	*	*	*	45	8.03	*	*	*	45	1.42	*	*	*
50	6.37	*	*	*	50	6.58	*	*	*	50	1.42	*	*	*
R.M.S. FLUCTUATION														
0	0.00	*	*	*	0	0.00	*	*	*	0	0.00	*	*	*
5	0.22	*	*	*	5	0.25	*	*	*	5	0.71	*	*	*
10	0.53	*	*	*	10	0.99	*	*	*	10	1.93	*	*	*
15	0.83	*	*	*	15	1.00	*	*	*	15	1.93	*	*	*
20	1.34	*	*	*	20	1.99	*	*	*	20	1.93	*	*	*
25	1.35	*	*	*	25	1.76	*	*	*	25	1.58	*	*	*
30	0.94	*	*	*	30	1.20	*	*	*	30	1.42	*	*	*
35	1.28	*	*	*	35	1.99	*	*	*	35	1.42	*	*	*
40	1.61	*	*	*	40	1.93	*	*	*	40	1.42	*	*	*
45	1.60	*	*	*	45	1.58	*	*	*	45	1.42	*	*	*
50	1.47	*	*	*	50	1.42	*	*	*	50	1.42	*	*	*

Table 6. (Cont.)

		I: PHI 40 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300		J: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300		AVERAGE GAIN FUNCTION (1.E+7)	
0	5.83	0.00 *	*	0	6.71	*	*
5	4.00	* 2.22	*	5	4.30	*	*
10	2.60	* 1.72	*	10	2.33	*	*
15	3.50	* 1.02	*	15	3.25	*	*
20	5.11	* .93	*	20	5.18	*	*
25	6.20	* .79	*	25	6.29	*	*
30	7.67	* .75	*	30	7.62	*	*
35	9.21	* .75	*	35	9.55	*	*
40	9.35	* .75	*	40	9.57	*	*
45	8.23	* .75	*	45	8.61	*	*
50	6.85	* .75	*	50	6.87	*	*
R.M.S. FLUCTUATION							
0	0.00	0.00	*	0	0.00	*	*
5	.22	.19	*	5	.56	*	*
10	.72	.56	*	10	1.13	*	*
15	1.02	1.02	*	15	1.13	*	*
20	.79	1.23	*	20	1.23	*	*
25	.93	1.24	*	25	1.24	*	*
30	1.75	1.68	*	30	1.68	*	*
35	2.30	1.99	*	35	1.99	*	*
40	1.95	1.92	*	40	1.92	*	*
45	1.57	1.67	*	45	1.67	*	*
50	1.42	1.41	*	50	1.41	*	*
AVERAGE GAIN FUNCTION (1.E+7)							
		K: PHI 50 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300		L: PHI 55 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300		AVERAGE GAIN FUNCTION (1.E+7)	
0	6.16	0.00 *	*	0	5.01	*	*
5	3.96	* 2.17	*	5	3.44	*	*
10	2.17	* 3.24	*	10	2.25	*	*
15	3.24	* 5.44	*	15	3.42	*	*
20	5.44	* 6.70	*	20	5.66	*	*
25	6.70	* 7.71	*	25	7.07	*	*
30	7.71	* 8.97	*	30	7.94	*	*
35	8.97	* 9.33	*	35	8.76	*	*
40	9.33	* 8.39	*	40	8.87	*	*
45	8.39	* 6.86	*	45	8.00	*	*
50	6.86	* .00	*	50	6.69	*	*
R.M.S. FLUCTUATION							
0	0.00	0.00	*	0	0.00	*	*
5	.15	.09	*	5	.09	*	*
10	.39	.24	*	10	.24	*	*
15	.90	.50	*	15	.50	*	*
20	1.37	1.06	*	20	1.06	*	*
25	1.56	1.60	*	25	1.60	*	*
30	1.81	1.87	*	30	1.87	*	*
35	1.96	2.06	*	35	2.06	*	*
40	1.90	2.07	*	40	2.07	*	*
45	1.84	1.97	*	45	1.97	*	*
50	1.59	1.79	*	50	1.79	*	*

Table 6. (Cont.)

m:	PHI	60	DIHEDRAL ANGLE	2.00	WAVELENGTH	5300	n:	PHI	0	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943
AVERAGE GAIN FUNCTION (1.E+7)													
0	4.44	*	*	*	*	*	0	10.52	*	*	*	*	*
5	3.45	*	*	*	*	*	5	10.29	*	*	*	*	*
10	2.76	*	*	*	*	*	10	9.80	*	*	*	*	*
15	3.77	*	*	*	*	*	15	9.05	*	*	*	*	*
20	5.69	*	*	*	*	*	20	8.14	*	*	*	*	*
25	7.11	*	*	*	*	*	25	7.18	*	*	*	*	*
30	7.97	*	*	*	*	*	30	6.23	*	*	*	*	*
35	8.55	*	*	*	*	*	35	5.34	*	*	*	*	*
40	8.47	*	*	*	*	*	40	4.52	*	*	*	*	*
45	7.57	*	*	*	*	*	45	3.78	*	*	*	*	*
50	6.30	*	*	*	*	*	50	3.11	*	*	*	*	*
R.M.S. FLUCTUATION													
0	0.00	*	*	*	*	*	0	0.00	*	*	*	*	*
5	0.07	*	*	*	*	*	5	0.02	*	*	*	*	*
10	0.23	*	*	*	*	*	10	0.02	*	*	*	*	*
15	0.52	*	*	*	*	*	15	0.01	*	*	*	*	*
20	0.82	*	*	*	*	*	20	0.01	*	*	*	*	*
25	1.34	*	*	*	*	*	25	0.01	*	*	*	*	*
30	1.81	*	*	*	*	*	30	0.01	*	*	*	*	*
35	2.09	*	*	*	*	*	35	0.01	*	*	*	*	*
40	2.21	*	*	*	*	*	40	0.00	*	*	*	*	*
45	2.12	*	*	*	*	*	45	0.00	*	*	*	*	*
50	1.89	*	*	*	*	*	50	0.00	*	*	*	*	*
AVERAGE GAIN FUNCTION (1.E+7)													
0	10.49	*	*	*	*	*	0	10.14	*	*	*	*	*
5	10.25	*	*	*	*	*	5	9.87	*	*	*	*	*
10	9.71	*	*	*	*	*	10	9.31	*	*	*	*	*
15	8.92	*	*	*	*	*	15	8.54	*	*	*	*	*
20	8.01	*	*	*	*	*	20	7.68	*	*	*	*	*
25	7.05	*	*	*	*	*	25	6.81	*	*	*	*	*
30	6.12	*	*	*	*	*	30	5.96	*	*	*	*	*
35	5.24	*	*	*	*	*	35	5.15	*	*	*	*	*
40	4.43	*	*	*	*	*	40	4.44	*	*	*	*	*
45	3.70	*	*	*	*	*	45	3.85	*	*	*	*	*
50	3.07	*	*	*	*	*	50	3.37	*	*	*	*	*
R.M.S. FLUCTUATION													
0	0.00	*	*	*	*	*	0	0.00	*	*	*	*	*
5	0.03	*	*	*	*	*	5	0.08	*	*	*	*	*
10	0.08	*	*	*	*	*	10	0.31	*	*	*	*	*
15	0.16	*	*	*	*	*	15	0.61	*	*	*	*	*
20	0.25	*	*	*	*	*	20	0.87	*	*	*	*	*
25	0.32	*	*	*	*	*	25	1.01	*	*	*	*	*
30	0.35	*	*	*	*	*	30	0.96	*	*	*	*	*
35	0.33	*	*	*	*	*	35	0.78	*	*	*	*	*
40	0.26	*	*	*	*	*	40	0.55	*	*	*	*	*
45	0.17	*	*	*	*	*	45	0.39	*	*	*	*	*
50	0.11	*	*	*	*	*	50	0.38	*	*	*	*	*

Table 6. (Cont.)

q: PHI 15		DIHEDRAL ANGLE 2.00		WAVELENGTH 6943		r: PHI 20		DIHEDRAL ANGLE 2.00		WAVELENGTH 6943	
AVERAGE GAIN FUNCTION (1.E+7)						AVERAGE GAIN FUNCTION (1.E+7)					
0	10.16	*	*	*	*	0	11.28	*	*	*	*
5	9.77	*	*	*	*	5	10.51	*	*	*	*
10	9.01	*	*	*	*	10	9.14	*	*	*	*
15	8.12	*	*	*	*	15	7.77	*	*	*	*
20	7.33	*	*	*	*	20	6.96	*	*	*	*
25	6.69	*	*	*	*	25	6.72	*	*	*	*
30	6.13	*	*	*	*	30	6.69	*	*	*	*
35	5.60	*	*	*	*	35	6.52	*	*	*	*
40	5.09	*	*	*	*	40	6.08	*	*	*	*
45	4.62	*	*	*	*	45	5.43	*	*	*	*
50	4.14	*	*	*	*	50	4.65	*	*	*	*
R.M.S. FLUCTUATION											
0	0.00	*	*	*	*	0	0.00	*	*	*	*
5	4.16	*	*	*	*	5	*.21	*	*	*	*
10	*.59	*	*	*	*	10	*.75	*	*	*	*
15	1.10	*	*	*	*	15	1.33	*	*	*	*
20	1.44	*	*	*	*	20	1.60	*	*	*	*
25	1.44	*	*	*	*	25	1.38	*	*	*	*
30	1.13	*	*	*	*	30	*.92	*	*	*	*
35	*.77	*	*	*	*	35	*.92	*	*	*	*
40	*.67	*	*	*	*	40	1.14	*	*	*	*
45	*.74	*	*	*	*	45	1.13	*	*	*	*
50	*.79	*	*	*	*	50	1.03	*	*	*	*
R.M.S. FLUCTUATION											
0	0.00	*	*	*	*	0	0.00	*	*	*	*
5	5	*	*	*	*	5	10.67	*	*	*	*
10	8.94	*	*	*	*	10	8.32	*	*	*	*
15	7.19	*	*	*	*	15	6.55	*	*	*	*
20	6.55	*	*	*	*	20	6.35	*	*	*	*
25	6.85	*	*	*	*	25	7.21	*	*	*	*
30	7.29	*	*	*	*	30	7.87	*	*	*	*
35	7.27	*	*	*	*	35	7.65	*	*	*	*
40	6.65	*	*	*	*	40	6.76	*	*	*	*
45	5.72	*	*	*	*	45	5.75	*	*	*	*
50	4.75	*	*	*	*	50	4.91	*	*	*	*
R.M.S. FLUCTUATION											
0	0.00	*	*	*	*	0	0.00	*	*	*	*
5	*.22	*	*	*	*	5	*.21	*	*	*	*
10	*.69	*	*	*	*	10	*.55	*	*	*	*
15	1.15	*	*	*	*	15	*.84	*	*	*	*
20	1.26	*	*	*	*	20	*.90	*	*	*	*
25	1.00	*	*	*	*	25	1.00	*	*	*	*
30	*.98	*	*	*	*	30	1.32	*	*	*	*
35	1.32	*	*	*	*	35	1.47	*	*	*	*
40	1.37	*	*	*	*	40	1.31	*	*	*	*
45	1.18	*	*	*	*	45	1.10	*	*	*	*
50	1.06	*	*	*	*	50	1.00	*	*	*	*

Table 6. (Cont.)

AVERAGE GAIN FUNCTION (1.E+7)						AVERAGE GAIN FUNCTION (1.E+7)						AVERAGE GAIN FUNCTION (1.E+7)					
U: PHI	35	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	V: PHI	40	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	X: PHI	50	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943
0	11.32	*	*	*	*	0	10.45	*	*	*	*	0	0.00	*	*	*	*
5	9.73	*	*	*	*	5	8.74	*	*	*	*	5	0.00	*	*	*	*
10	7.33	*	*	*	*	10	6.36	*	*	*	*	10	0.00	*	*	*	*
15	5.93	*	*	*	*	15	5.42	*	*	*	*	15	0.00	*	*	*	*
20	6.39	*	*	*	*	20	6.48	*	*	*	*	20	0.00	*	*	*	*
25	7.66	*	*	*	*	25	8.00	*	*	*	*	25	0.00	*	*	*	*
30	8.23	*	*	*	*	30	8.38	*	*	*	*	30	0.00	*	*	*	*
35	7.71	*	*	*	*	35	7.70	*	*	*	*	35	0.00	*	*	*	*
40	6.75	*	*	*	*	40	6.91	*	*	*	*	40	0.00	*	*	*	*
45	5.97	*	*	*	*	45	6.41	*	*	*	*	45	0.00	*	*	*	*
50	5.35	*	*	*	*	50	5.78	*	*	*	*	50	0.00	*	*	*	*
R.M.S. FLUCTUATION																	
0	0.00	*	*	*	*	0	0.00	*	*	*	*	0	0.00	*	*	*	*
5	0.21	*	*	*	*	5	0.20	*	*	*	*	5	0.00	*	*	*	*
10	0.55	*	*	*	*	10	0.64	*	*	*	*	10	0.00	*	*	*	*
15	0.97	*	*	*	*	15	1.33	*	*	*	*	15	0.00	*	*	*	*
20	1.30	*	*	*	*	20	1.88	*	*	*	*	20	0.00	*	*	*	*
25	1.47	*	*	*	*	25	1.90	*	*	*	*	25	0.00	*	*	*	*
30	1.48	*	*	*	*	30	1.50	*	*	*	*	30	0.00	*	*	*	*
35	1.34	*	*	*	*	35	1.21	*	*	*	*	35	0.00	*	*	*	*
40	1.15	*	*	*	*	40	1.24	*	*	*	*	40	0.00	*	*	*	*
45	1.09	*	*	*	*	45	1.41	*	*	*	*	45	0.00	*	*	*	*
50	1.11	*	*	*	*	50	1.37	*	*	*	*	50	0.00	*	*	*	*
R.M.S. FLUCTUATION																	
0	11.15	*	*	*	*	0	11.30	*	*	*	*	0	0.00	*	*	*	*
5	9.11	*	*	*	*	5	9.33	*	*	*	*	5	0.00	*	*	*	*
10	6.26	*	*	*	*	10	6.49	*	*	*	*	10	0.00	*	*	*	*
15	5.06	*	*	*	*	15	5.12	*	*	*	*	15	0.00	*	*	*	*
20	6.26	*	*	*	*	20	6.11	*	*	*	*	20	0.00	*	*	*	*
25	6.06	*	*	*	*	25	7.90	*	*	*	*	25	0.00	*	*	*	*
30	8.56	*	*	*	*	30	8.13	*	*	*	*	30	0.00	*	*	*	*
35	7.85	*	*	*	*	35	8.33	*	*	*	*	35	0.00	*	*	*	*
40	7.00	*	*	*	*	40	7.04	*	*	*	*	40	0.00	*	*	*	*
45	6.48	*	*	*	*	45	6.29	*	*	*	*	45	0.00	*	*	*	*
50	5.87	*	*	*	*	50	5.63	*	*	*	*	50	0.00	*	*	*	*
R.M.S. FLUCTUATION																	
0	0.00	*	*	*	*	0	0.00	*	*	*	*	0	0.00	*	*	*	*
5	0.19	*	*	*	*	5	0.17	*	*	*	*	5	0.00	*	*	*	*
10	0.41	*	*	*	*	10	0.22	*	*	*	*	10	0.00	*	*	*	*
15	1.05	*	*	*	*	15	0.52	*	*	*	*	15	0.00	*	*	*	*
20	1.73	*	*	*	*	20	0.98	*	*	*	*	20	0.00	*	*	*	*
25	1.95	*	*	*	*	25	1.38	*	*	*	*	25	0.00	*	*	*	*
30	1.62	*	*	*	*	30	1.47	*	*	*	*	30	0.00	*	*	*	*
35	1.26	*	*	*	*	35	1.30	*	*	*	*	35	0.00	*	*	*	*
40	1.32	*	*	*	*	40	1.25	*	*	*	*	40	0.00	*	*	*	*
45	1.44	*	*	*	*	45	1.32	*	*	*	*	45	0.00	*	*	*	*
50	1.30	*	*	*	*	50	1.24	*	*	*	*	50	0.00	*	*	*	*

Table 6. (Cont.)

AVERAGE GAIN FUNCTION (1.E+7)

R.M.S. FLUCTUATION	AVERAGE GAIN FUNCTION (1.E+7)
0	1.000
5	1.14
10	1.17
15	1.32
20	1.35
25	1.47
30	1.87
35	1.15
40	1.19
45	1.18
50	1.17

AVERAGE GAIN FUNCTION (1.E+7)

z: PHI	DIHEDRAL ANGLE	WAVELENGTH	AVERAGE GAIN FUNCTION (1.E+7)
0	2.00	6943	11.24
5	2.00	6943	9.58
10	2.00	6943	7.96
15	2.00	6943	5.59
20	2.00	6943	6.20
25	2.00	6943	7.56
30	2.00	6943	8.37
35	2.00	6943	8.01
40	2.00	6943	7.96
45	2.00	6943	6.15
50	2.00	6943	5.35

R.M.S. FLUCTUATION

z: PHI	DIHEDRAL ANGLE	WAVELENGTH	R.M.S. FLUCTUATION
0	2.00	6943	0.00
5	2.00	6943	0.12
10	2.00	6943	0.26
15	2.00	6943	0.65
20	2.00	6943	1.04
25	2.00	6943	1.12
30	2.00	6943	0.89
35	2.00	6943	0.87
40	2.00	6943	1.07
45	2.00	6943	1.13
50	2.00	6943	1.09

AVERAGE GAIN FUNCTION (1.E+7)

Table 7. Sample gain-function matrices. The angles  $\theta_1$  and  $\theta_2$ , in microradians, are defined in Figure 8. Only half the matrix is presented since  $G(\theta_1, \theta_2) = G(-\theta_1, -\theta_2)$ .

$\theta_2$	GAIN FUNCTION (1.E+7)										
	0	5	10	15	20	25	30	35	40	45	50
0	2.90	2.87	2.78	2.66	2.50	2.34	2.18	2.03	1.90	1.78	1.66
5	3.60	3.56	3.43	3.23	2.99	2.73	2.48	2.26	2.07	1.91	1.78
10	4.50	4.44	4.27	3.99	3.65	3.27	2.90	2.56	2.29	2.07	1.90
15	5.52	5.45	5.23	4.89	4.44	3.94	3.43	2.96	2.56	2.26	2.03
20	6.58	6.49	6.24	5.83	5.30	4.69	4.05	3.43	2.90	2.48	2.18
25	7.60	7.50	7.21	6.75	6.15	5.45	4.69	3.94	3.27	2.73	2.34
30	8.56	8.45	8.12	7.60	6.93	6.15	5.30	4.44	3.65	2.99	2.50
35	9.46	9.32	8.93	8.34	7.60	6.75	5.83	4.89	3.99	3.23	2.66
40	10.22	10.05	9.60	8.93	8.12	7.21	6.24	5.23	4.27	3.43	2.78
45	10.75	10.57	10.05	9.32	8.45	7.50	6.49	5.45	4.44	3.56	2.87
50	10.94	10.75	10.22	9.46	8.56	7.60	6.58	5.52	4.50	3.60	2.90
-5	10.75	10.57	10.05	9.32	8.45	7.50	6.49	5.45	4.44	3.56	2.87
-10	10.22	10.05	9.60	8.93	8.12	7.21	6.24	5.23	4.27	3.43	2.78
-15	9.46	9.32	8.93	8.34	7.60	6.75	5.83	4.89	3.99	3.23	2.66
-20	8.56	8.45	8.12	7.60	6.93	6.15	5.30	4.44	3.65	2.99	2.50
-25	7.60	7.50	7.21	6.75	6.15	5.45	4.69	3.94	3.27	2.73	2.34
-30	6.58	6.49	6.24	5.83	5.30	4.69	4.05	3.43	2.90	2.48	2.18
-35	5.52	5.45	5.23	4.89	4.44	3.94	3.43	2.96	2.56	2.26	2.03
-40	4.50	4.44	4.27	3.99	3.65	3.27	2.90	2.56	2.29	2.07	1.90
-45	3.60	3.56	3.43	3.23	2.99	2.73	2.48	2.26	2.07	1.91	1.78
-50	2.90	2.87	2.78	2.66	2.50	2.34	2.18	2.03	1.90	1.78	1.66

b: PHI 25 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300

$\theta_2$	GAIN FUNCTION (1.E+7)										
	0	5	10	15	20	25	30	35	40	45	50
0	6.54	6.95	7.18	7.20	7.05	6.79	6.36	5.68	4.74	3.72	2.81
5	7.41	7.95	8.27	8.35	8.23	7.98	7.58	6.92	5.94	4.78	3.62
10	7.77	8.32	8.67	8.84	8.83	8.64	8.24	7.58	6.65	5.52	4.29
15	8.58	8.88	9.04	9.20	9.28	9.15	8.68	7.89	6.90	5.83	4.68
20	9.79	9.62	9.53	9.66	9.82	9.73	9.20	8.20	7.00	5.88	4.82
25	9.76	9.30	9.31	9.69	10.03	10.05	9.60	8.58	7.21	5.93	4.87
30	7.40	7.21	7.81	8.73	9.34	9.52	9.39	8.75	7.53	6.16	4.99
35	4.25	4.68	5.83	7.12	7.84	8.10	8.44	8.55	7.86	6.58	5.28
40	2.93	3.66	4.62	5.63	6.13	6.36	7.16	8.14	8.16	7.12	5.70
45	3.81	4.09	4.15	4.53	4.76	4.99	6.15	7.78	8.37	7.53	6.05
50	4.60	4.08	3.49	3.69	4.04	4.41	5.72	7.56	8.29	7.52	6.07
-5	3.81	2.98	2.73	3.53	4.27	4.73	5.86	7.34	7.78	6.94	5.63
-10	2.93	2.63	3.39	4.82	5.59	5.72	6.25	6.98	6.88	5.95	4.89
-15	4.25	4.77	6.12	7.29	7.33	6.73	6.50	6.42	5.81	4.89	4.13
-20	7.40	8.27	9.17	9.22	8.23	7.05	6.33	5.71	4.82	4.03	3.51
-25	9.76	10.25	10.15	9.16	7.71	6.56	5.81	4.99	4.07	3.43	3.04
-30	9.79	9.62	8.82	7.60	6.52	5.87	5.29	4.46	3.59	3.05	2.67
-35	8.58	7.96	7.08	6.28	5.84	5.56	5.01	4.13	3.32	2.79	2.36
-40	7.77	7.06	6.41	6.02	5.84	5.50	4.76	3.83	3.06	2.53	2.05
-45	7.41	6.81	6.32	6.01	5.67	5.06	4.17	3.30	2.65	2.14	1.69
-50	6.54	6.06	5.62	5.22	4.69	3.97	3.18	2.54	2.05	1.64	1.28

0 5 10 15 20 25 30 35 40 45 50  $\theta_1$

Table 7. (Cont.)

c: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300

$\theta_2$	GAIN FUNCTION (1.E+7)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	7.25	7.87	8.31	8.48	8.24	7.57	6.43	4.98	3.58	2.56	1.92
45	9.69	10.40	10.80	10.74	10.20	9.34	8.16	6.57	4.80	3.39	2.50
40	11.40	12.23	12.87	12.82	11.78	10.31	8.98	7.55	5.82	4.24	3.13
35	10.23	11.54	13.30	14.26	13.37	11.31	9.51	8.11	6.55	5.02	3.83
30	7.56	9.19	11.70	13.61	13.42	11.59	9.83	8.50	7.04	5.55	4.38
25	6.73	7.94	9.58	10.88	10.87	9.96	9.23	8.58	7.35	5.82	4.59
20	6.90	7.45	7.88	7.93	7.46	7.18	7.67	8.14	7.54	6.13	4.75
15	4.87	5.23	5.54	5.54	5.06	4.93	5.98	7.35	7.58	6.57	5.16
10	2.90	2.91	2.88	3.42	3.79	4.05	5.23	6.89	7.47	6.78	5.58
5	4.72	3.56	1.73	2.05	3.50	4.64	5.99	7.34	7.45	6.56	5.66
0	6.71	4.57	1.53	1.73	4.03	5.95	7.40	8.23	7.62	6.35	5.63
-5	4.72	3.00	1.19	2.25	4.78	6.66	7.99	8.66	7.97	6.68	5.90
-10	2.90	2.26	2.24	3.64	5.28	6.45	7.72	8.75	8.56	7.46	6.33
-15	4.87	4.59	4.73	5.21	5.62	6.31	7.76	9.13	9.17	7.96	6.37
-20	6.90	6.37	6.12	6.19	6.41	7.12	8.48	9.52	9.16	7.66	5.94
-25	6.73	6.19	6.52	7.38	7.98	8.32	8.84	9.06	8.22	6.72	5.30
-30	7.56	7.21	8.01	9.02	9.05	8.36	7.94	7.64	6.77	5.56	4.51
-35	10.23	9.73	9.75	9.47	8.31	6.96	6.37	6.11	5.37	4.37	3.49
-40	11.40	10.53	9.50	8.13	6.58	5.52	5.21	4.92	4.11	3.13	2.36
-45	9.69	8.72	7.54	6.26	5.19	4.57	4.23	3.66	2.76	1.94	1.40
-50	7.25	6.50	5.63	4.75	3.97	3.36	2.79	2.14	1.49	1.02	.75

d: PHI 60 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300

$\theta_2$	GAIN FUNCTION (1.E+7)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	6.30	7.18	7.69	7.77	7.33	6.43	5.28	3.95	2.62	1.59	.99
45	6.63	7.73	8.70	9.22	8.99	8.04	6.66	5.04	3.44	2.16	1.34
40	6.79	8.07	9.59	10.71	10.81	9.83	8.10	6.07	4.20	2.77	1.79
35	7.18	8.64	10.41	11.74	11.96	10.96	9.01	6.66	4.63	3.22	2.23
30	7.69	9.29	10.86	11.73	11.63	10.64	8.86	6.61	4.63	3.35	2.48
25	7.31	8.98	10.27	10.54	9.88	8.89	7.68	6.06	4.38	3.24	2.54
20	5.33	6.91	8.33	8.62	7.72	6.72	6.15	5.44	4.28	3.26	2.66
15	2.98	4.09	5.69	6.63	6.16	5.26	5.15	5.32	4.80	3.86	3.19
10	2.34	2.58	3.63	5.08	5.47	5.01	5.24	6.08	6.12	5.23	4.29
5	3.56	2.94	2.84	4.23	5.46	5.70	6.36	7.65	8.04	7.07	5.75
0	4.44	3.59	2.87	4.13	5.91	6.86	7.98	9.52	9.97	8.83	7.15
-5	3.56	3.15	3.02	4.62	6.72	8.10	9.50	11.00	11.27	9.97	8.14
-10	2.34	2.37	3.22	5.33	7.58	9.14	10.50	11.61	11.54	10.24	8.52
-15	2.98	2.77	3.76	5.83	8.06	9.72	10.84	11.34	10.90	9.72	8.26
-20	5.33	4.41	4.61	6.01	8.02	9.69	10.52	10.48	9.78	8.73	7.44
-25	7.31	5.94	5.42	6.10	7.67	9.09	9.61	9.32	8.59	7.55	6.25
-30	7.69	6.47	5.90	6.22	7.21	8.06	8.29	8.02	7.39	6.31	4.93
-35	7.18	6.28	5.90	6.05	6.51	6.79	6.77	6.60	6.10	5.03	3.70
-40	6.79	5.90	5.39	5.29	5.41	5.40	5.28	5.14	4.70	3.74	2.65
-45	6.63	5.49	4.54	4.11	4.08	4.05	3.93	3.76	3.34	2.57	1.81
-50	6.30	5.06	3.82	3.11	2.90	2.84	2.73	2.57	2.21	1.66	1.17

0 5 10 15 20 25 30 35 40 45 50  $\theta_1$

Table 7. (Cont.)

e: PHI 0 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

$\theta_2$	GAIN FUNCTION (1.E+7)											
50	3.11	3.08	2.99	2.84	2.65	2.43	2.18	1.93	1.68	1.46	1.26	
45	3.78	3.74	3.63	3.45	3.21	2.93	2.63	2.31	2.00	1.71	1.46	
40	4.52	4.47	4.33	4.11	3.82	3.48	3.11	2.73	2.36	2.00	1.68	
35	5.34	5.28	5.10	4.83	4.47	4.07	3.63	3.18	2.73	2.31	1.93	
30	6.24	6.16	5.94	5.60	5.16	4.67	4.15	3.63	3.11	2.63	2.18	
25	7.19	7.10	6.82	6.40	5.87	5.28	4.67	4.07	3.48	2.93	2.43	
20	8.16	8.05	7.71	7.19	6.56	5.87	5.16	4.47	3.82	3.21	2.65	
15	9.08	8.94	8.54	7.93	7.19	6.40	5.60	4.83	4.11	3.45	2.84	
10	9.84	9.68	9.22	8.54	7.71	6.82	5.94	5.10	4.33	3.63	2.99	
5	10.34	10.17	9.68	8.94	8.05	7.10	6.16	5.28	4.47	3.74	3.08	
0	10.52	10.34	9.84	9.08	8.16	7.19	6.24	5.34	4.52	3.78	3.11	
-5	10.34	10.17	9.68	8.94	8.05	7.10	6.16	5.28	4.47	3.74	3.08	
-10	9.84	9.68	9.22	8.54	7.71	6.82	5.94	5.10	4.33	3.63	2.99	
-15	9.08	8.94	8.54	7.93	7.19	6.40	5.60	4.83	4.11	3.45	2.84	
-20	8.16	8.05	7.71	7.19	6.56	5.87	5.16	4.47	3.82	3.21	2.65	
-25	7.19	7.10	6.82	6.40	5.87	5.28	4.67	4.07	3.48	2.93	2.43	
-30	6.24	6.16	5.94	5.60	5.16	4.67	4.15	3.63	3.11	2.63	2.18	
-35	5.34	5.28	5.10	4.83	4.47	4.07	3.63	3.18	2.73	2.31	1.93	
-40	4.52	4.47	4.33	4.11	3.82	3.48	3.11	2.73	2.36	2.00	1.68	
-45	3.78	3.74	3.63	3.45	3.21	2.93	2.63	2.31	2.00	1.71	1.46	
-50	3.11	3.08	2.99	2.84	2.65	2.43	2.18	1.93	1.68	1.46	1.26	
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$

f: PHI 25 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

$\theta_2$	GAIN FUNCTION (1.E+7)											
50	4.36	4.48	4.56	4.61	4.64	4.60	4.46	4.18	3.78	3.27	2.72	
45	5.77	5.81	5.81	5.82	5.80	5.69	5.45	5.06	4.51	3.83	3.11	
40	7.14	7.11	7.13	7.18	7.17	6.99	6.63	6.08	5.37	4.50	3.58	
35	7.72	7.72	7.93	8.22	8.37	8.22	7.74	7.04	6.18	5.17	4.08	
30	7.12	7.32	7.90	8.60	9.08	9.05	8.51	7.69	6.73	5.67	4.52	
25	5.88	6.38	7.33	8.42	9.20	9.32	8.77	7.86	6.88	5.89	4.79	
20	5.19	5.95	7.00	8.14	9.00	9.14	8.54	7.57	6.63	5.79	4.86	
15	6.07	6.83	7.51	8.20	8.74	8.72	8.00	6.98	6.11	5.47	4.79	
10	8.44	8.86	8.72	8.55	8.50	8.17	7.33	6.27	5.50	5.06	4.63	
5	10.98	10.81	9.73	8.69	8.10	7.54	6.65	5.63	4.95	4.68	4.44	
0	12.07	11.29	9.58	8.13	7.37	6.85	6.06	5.13	4.55	4.38	4.23	
-5	10.98	9.84	8.11	6.90	6.49	6.27	5.68	4.87	4.32	4.16	4.01	
-10	8.44	7.31	6.15	5.69	5.89	6.04	5.61	4.64	4.26	4.00	3.76	
-15	6.07	5.30	4.94	5.30	6.00	6.29	5.83	4.98	4.29	3.88	3.50	
-20	5.19	4.88	5.19	6.00	6.75	6.83	6.13	5.12	4.29	3.73	3.21	
-25	5.88	5.93	6.49	7.23	7.59	7.20	6.19	5.05	4.15	3.49	2.88	
-30	7.12	7.32	7.74	8.03	7.80	6.96	5.77	4.65	3.79	3.13	2.51	
-35	7.72	7.86	7.95	7.74	7.06	6.02	4.90	3.98	3.28	2.69	2.12	
-40	7.14	7.14	6.94	6.42	5.62	4.69	3.87	3.24	2.74	2.26	1.76	
-45	5.77	5.63	5.29	4.75	4.09	3.47	2.99	2.63	2.29	1.90	1.49	
-50	4.36	4.14	3.81	3.40	3.00	2.68	2.45	2.24	1.98	1.64	1.29	
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$

Table 7. (Cont.)

g: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943											
$\theta_2$	GAIN FUNCTION (1.E+7)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	5.31	5.79	6.50	7.15	7.33	6.78	5.68	4.46	3.45	2.72	2.12
45	5.59	6.26	7.36	8.51	9.13	8.75	7.46	5.83	4.40	3.36	2.58
40	6.32	7.02	8.11	9.31	10.04	9.80	8.55	6.82	5.21	3.97	3.03
35	8.28	8.80	9.39	9.97	10.21	9.74	8.53	6.96	5.51	4.33	3.36
30	10.54	10.82	10.88	10.70	10.19	9.20	7.84	6.44	5.28	4.37	3.56
25	10.89	11.13	11.14	10.83	10.06	8.77	7.20	5.81	4.86	4.25	3.68
20	8.67	9.02	9.35	9.56	9.33	8.39	6.90	5.49	4.62	4.21	3.86
15	6.28	6.54	6.76	7.26	7.79	7.69	6.75	5.54	4.77	4.50	4.25
10	6.69	6.39	5.45	5.23	5.98	6.72	6.60	5.90	5.38	5.20	4.89
5	9.50	8.35	5.73	4.16	4.60	5.88	6.56	6.47	6.25	6.11	5.61
0	11.15	9.42	5.89	3.62	3.92	5.53	6.70	7.00	6.96	6.79	6.10
-5	9.50	7.86	4.92	3.31	4.01	5.75	6.91	7.18	7.09	6.86	6.12
-10	6.69	5.64	4.20	3.89	5.01	6.40	7.01	6.86	6.57	6.29	5.67
-15	6.28	5.78	5.47	5.84	6.65	7.12	6.85	6.19	5.71	5.46	5.04
-20	8.67	8.34	8.17	8.16	8.03	7.45	6.46	5.52	4.99	4.77	4.47
-25	10.89	10.45	9.88	9.23	8.39	7.31	6.14	5.19	4.65	4.36	4.02
-30	10.54	10.00	9.33	8.64	7.94	7.09	6.12	5.23	4.57	4.07	3.55
-35	8.28	7.84	7.56	7.49	7.42	7.04	6.24	5.24	4.33	3.61	2.96
-40	6.32	6.06	6.25	6.73	7.06	6.62	5.92	4.72	3.67	2.89	2.28
-45	5.59	5.45	5.75	6.21	6.38	5.90	4.83	3.64	2.71	2.10	1.66
-50	5.31	5.15	5.23	5.30	5.05	4.34	3.35	2.44	1.85	1.50	1.22

h: PHI 60 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943											
$\theta_2$	GAIN FUNCTION (1.E+7)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	4.76	5.13	5.56	5.94	6.07	5.79	5.11	4.14	3.09	2.12	1.38
45	6.26	6.66	6.98	7.14	7.01	6.51	5.67	4.60	3.44	2.36	1.51
40	7.59	8.02	8.21	8.09	7.61	6.81	5.79	4.68	3.55	2.49	1.62
35	8.05	8.52	8.72	8.52	7.85	6.80	5.60	4.47	3.46	2.54	1.76
30	7.27	7.79	8.21	8.31	7.81	6.74	5.42	4.23	3.34	2.64	2.00
25	5.75	6.24	6.98	7.62	7.67	6.68	5.55	4.29	3.44	2.91	2.42
20	4.75	5.06	5.83	6.87	7.55	7.28	6.14	4.81	3.90	3.44	3.05
15	5.40	5.30	5.57	6.48	7.53	7.83	7.04	5.75	4.75	4.25	3.87
10	7.67	7.08	6.38	6.57	7.58	8.32	7.99	6.87	5.81	5.21	4.77
5	10.24	9.27	7.61	6.93	7.65	8.65	8.73	7.86	6.84	6.16	5.62
0	11.36	10.33	8.30	7.19	7.70	8.81	9.15	8.51	7.59	6.90	6.27
-5	10.24	9.51	7.90	7.10	7.72	8.84	9.25	8.75	7.94	7.28	6.60
-10	7.67	7.40	6.74	6.74	7.69	8.76	9.08	8.61	7.91	7.29	6.57
-15	5.40	5.46	5.66	6.39	7.54	8.47	8.65	8.20	7.58	6.97	6.19
-20	4.75	4.85	5.34	6.22	7.24	7.92	8.00	7.61	7.05	6.40	5.56
-25	5.75	5.60	5.77	6.22	6.76	7.13	7.16	6.88	6.38	5.69	4.80
-30	7.27	6.79	6.40	6.17	6.14	6.22	6.24	6.05	5.59	4.88	4.01
-35	8.05	7.37	6.60	5.92	5.50	5.37	5.34	5.16	4.71	4.03	3.26
-40	7.59	6.94	6.15	5.40	4.90	4.67	4.53	4.26	3.79	3.18	2.58
-45	6.26	5.77	5.22	4.70	4.33	4.08	3.82	3.43	2.91	2.41	1.97
-50	4.76	4.45	4.16	3.92	3.72	3.51	3.18	2.70	2.18	1.75	1.46

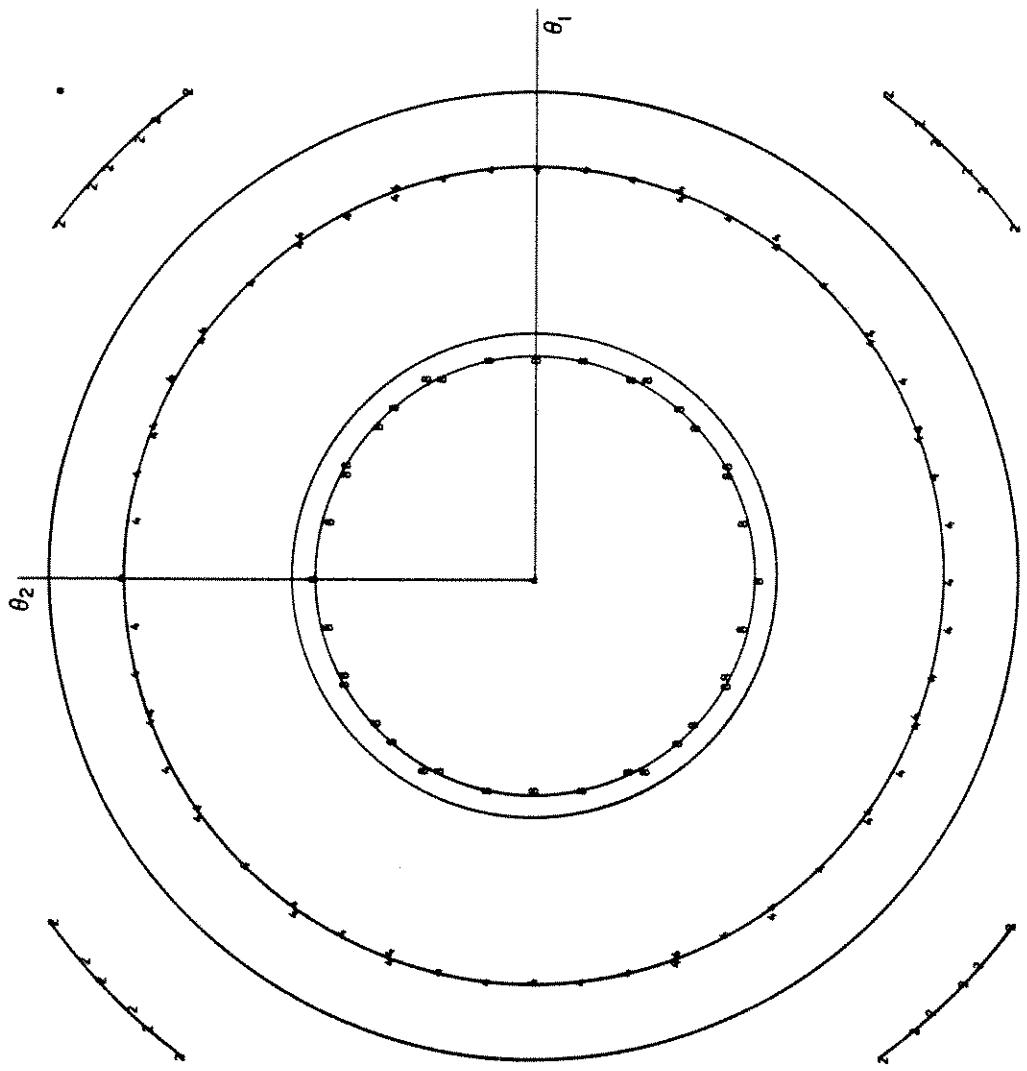


Figure 9. Contour plots of the gain-function matrices given in Table 7. Circles 25 and 50  $\mu$ rad in radius are shown to mark the minimum and maximum values of the velocity aberration. The numbers are the gain function in units of  $10^7$ . The incidence angle  $\phi$ , the dihedral-angle offset  $\delta$ , and the wavelength  $\lambda$  are given for each figure. a:  $\phi = 0^\circ$ ,  $\delta = 2^\circ 0'$ ,  $\lambda = 5300 \text{ \AA}$ .

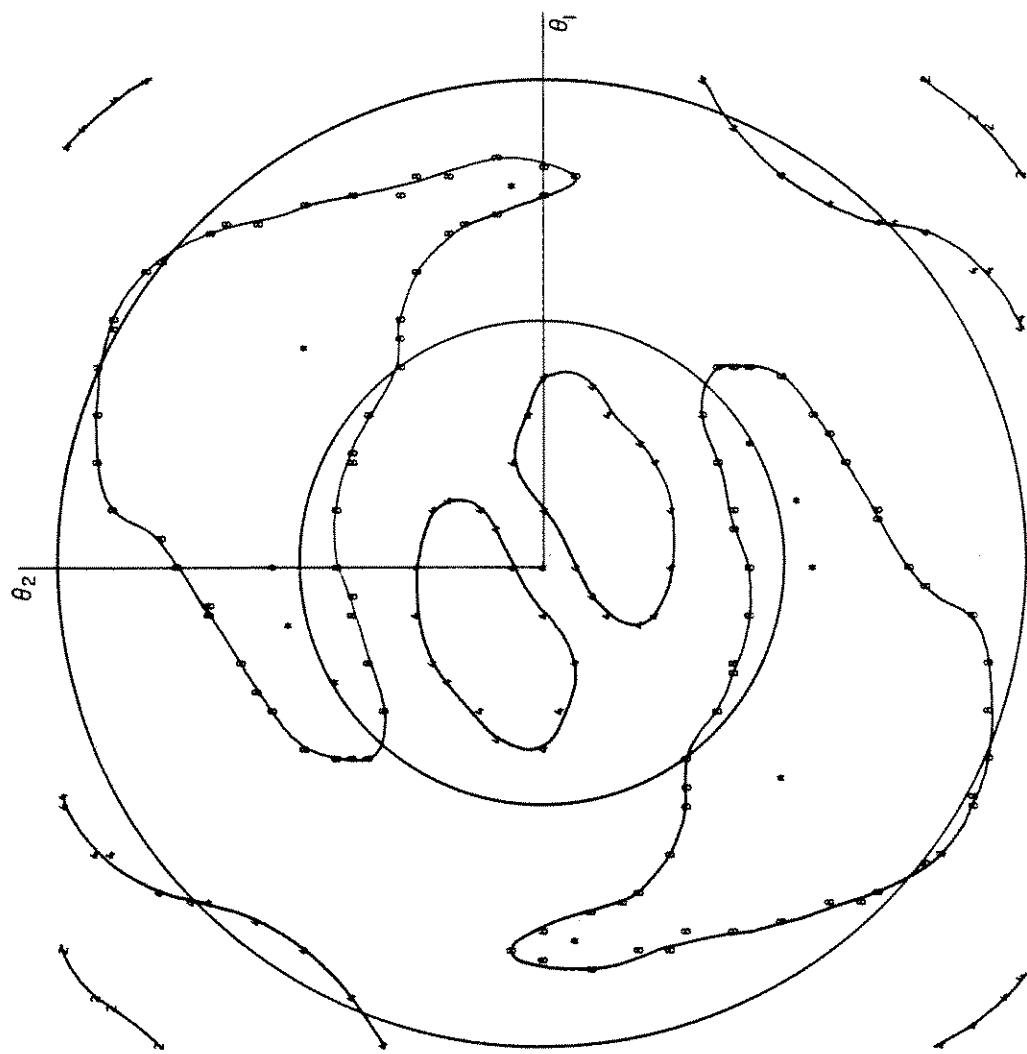


Figure 9b:  $\phi = 25^\circ$ ,  $\delta = 210^\circ$ ,  $\lambda = 5300 \text{ \AA}$ .

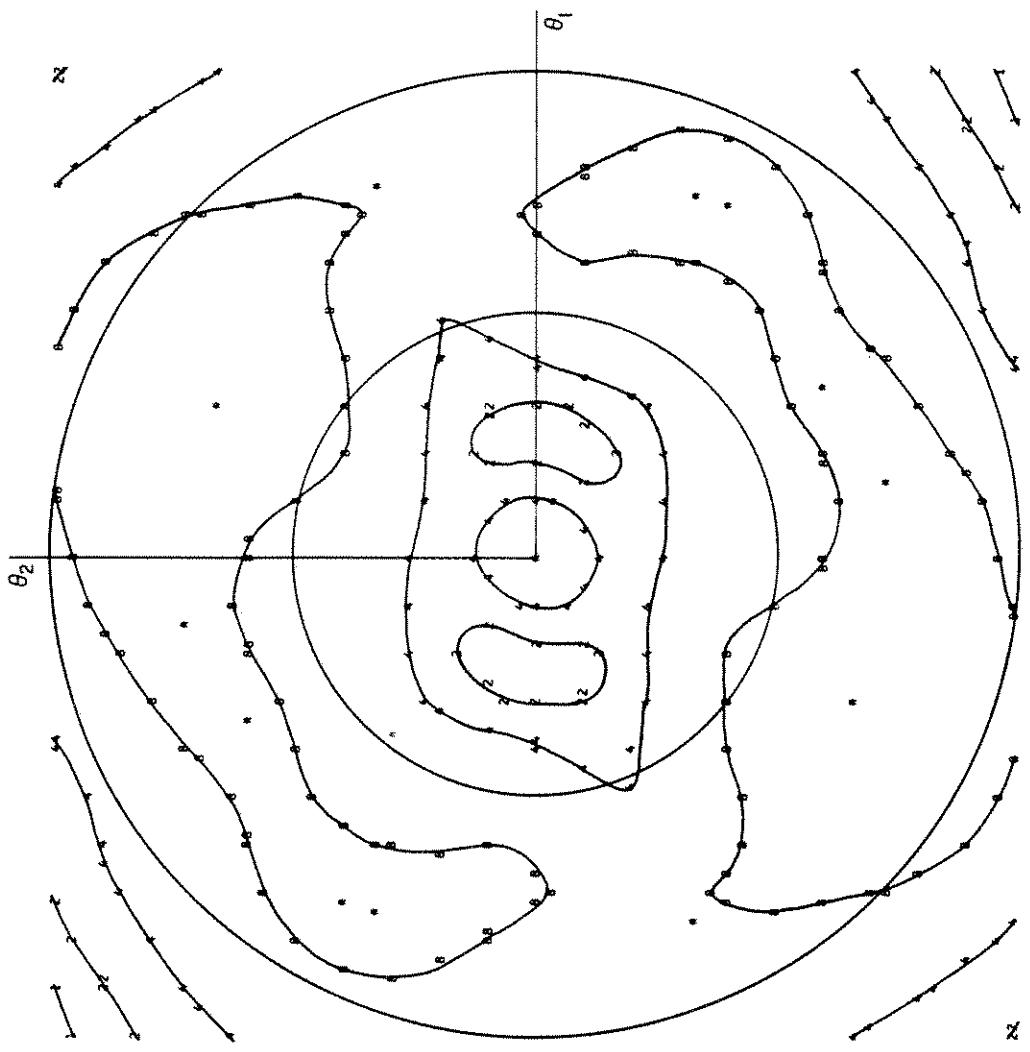


Figure 9c:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0'$ ,  $\lambda = 5300 \text{ \AA}$ .

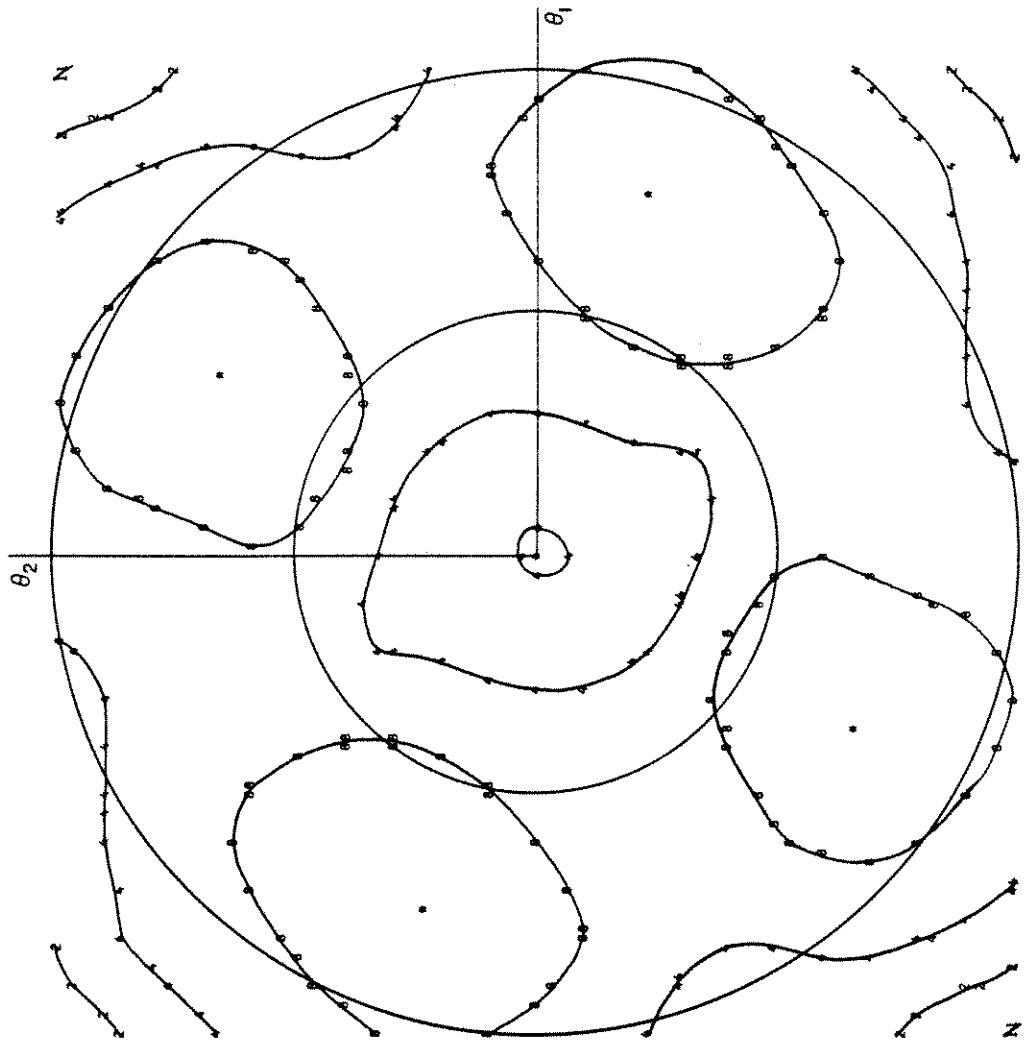


Figure 9d:  $\phi = 60^\circ$ ,  $\delta = 2^\circ 0$ ,  $\lambda = 5300 \text{ \AA}$ .

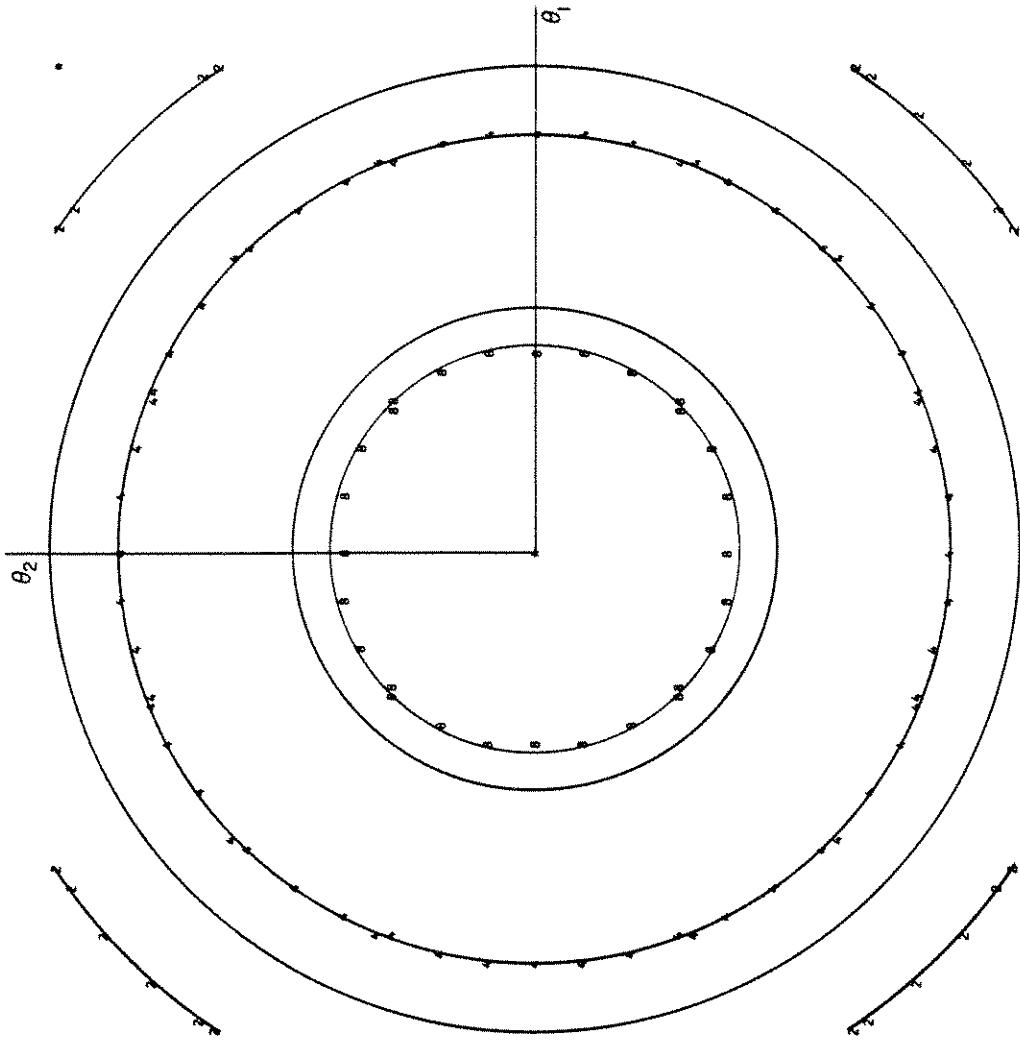


Figure 9e:  $\phi = 0^\circ$ ,  $\delta = 2^\circ 0'$ ,  $\lambda = 6943 \text{ \AA}$ .

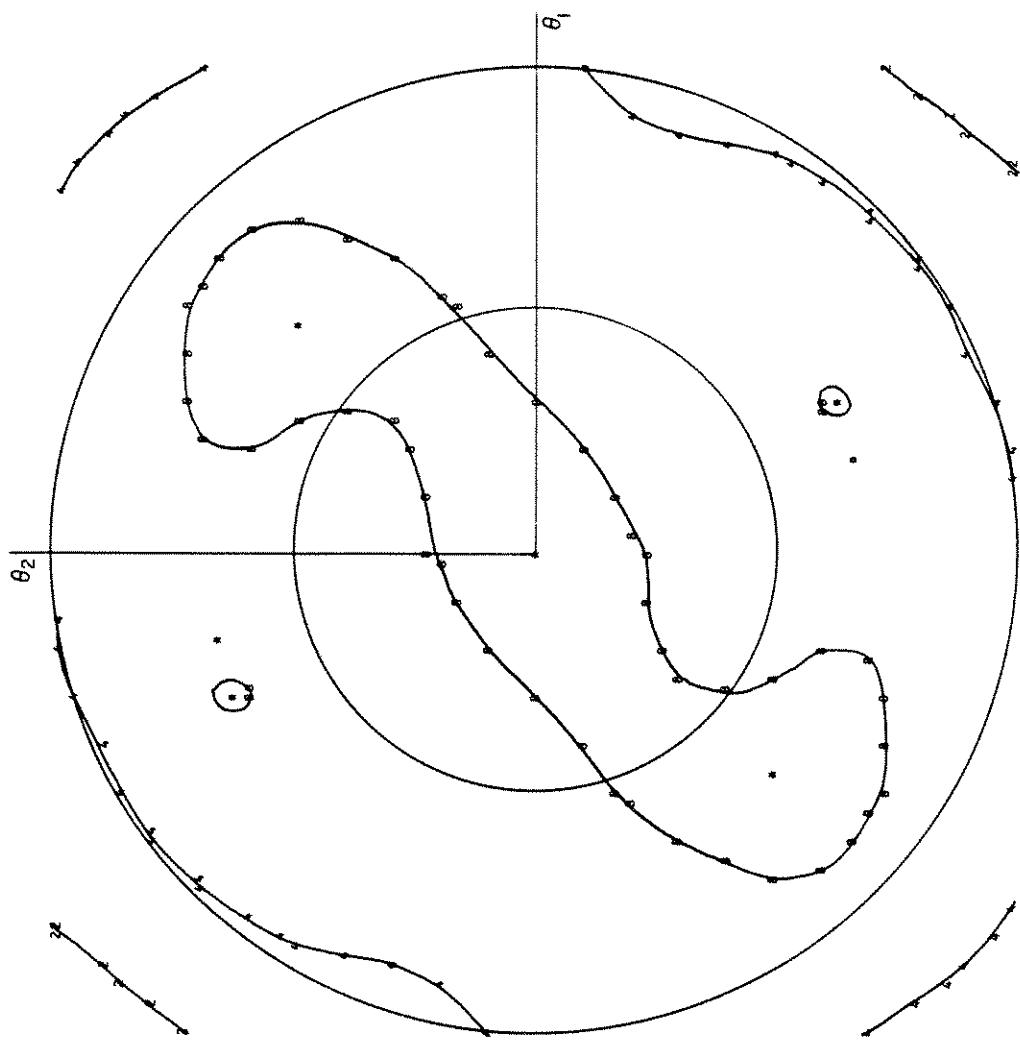


Figure 9f:  $\phi = 25^\circ$ ,  $\delta = 210$ ,  $\lambda = 6943 \text{ \AA}$ .

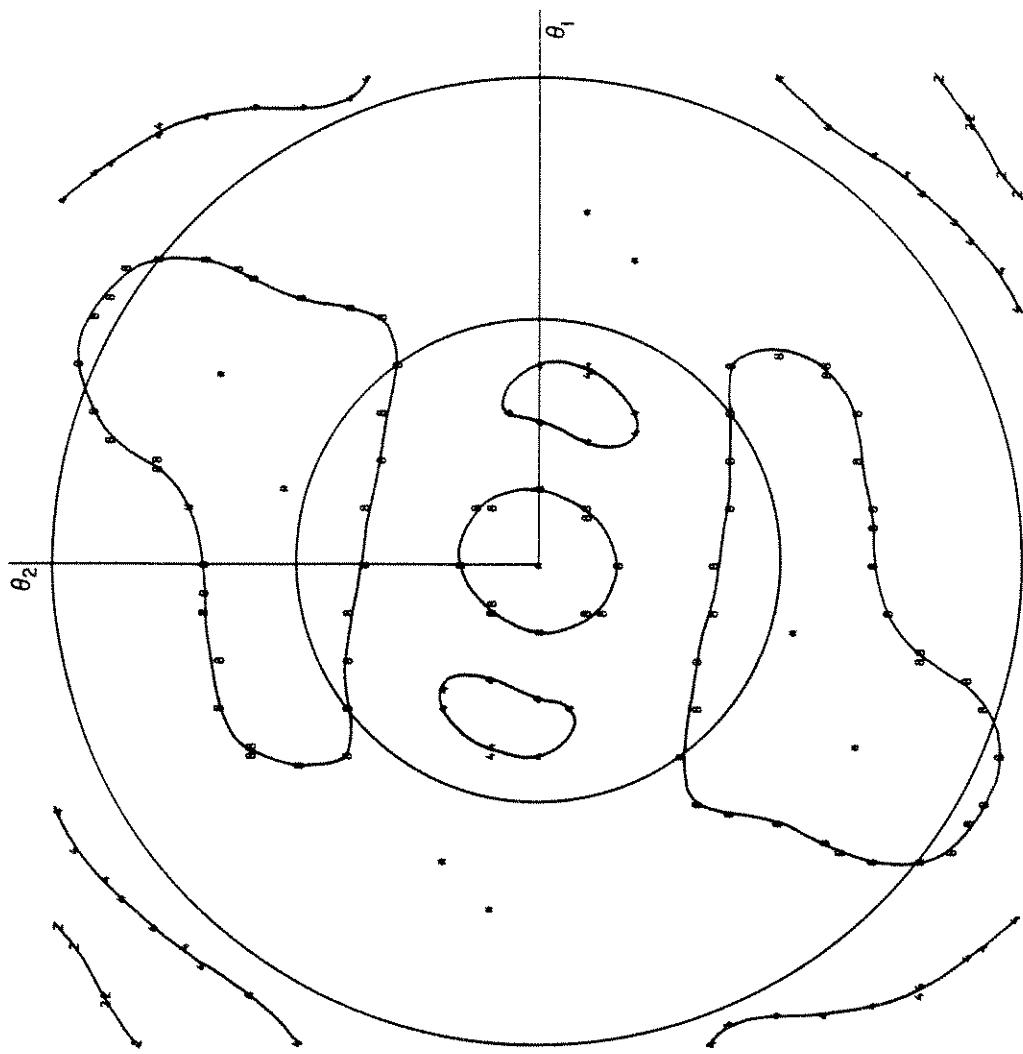


Figure 9g:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0'$ ,  $\lambda = 6943 \text{ \AA}$ .

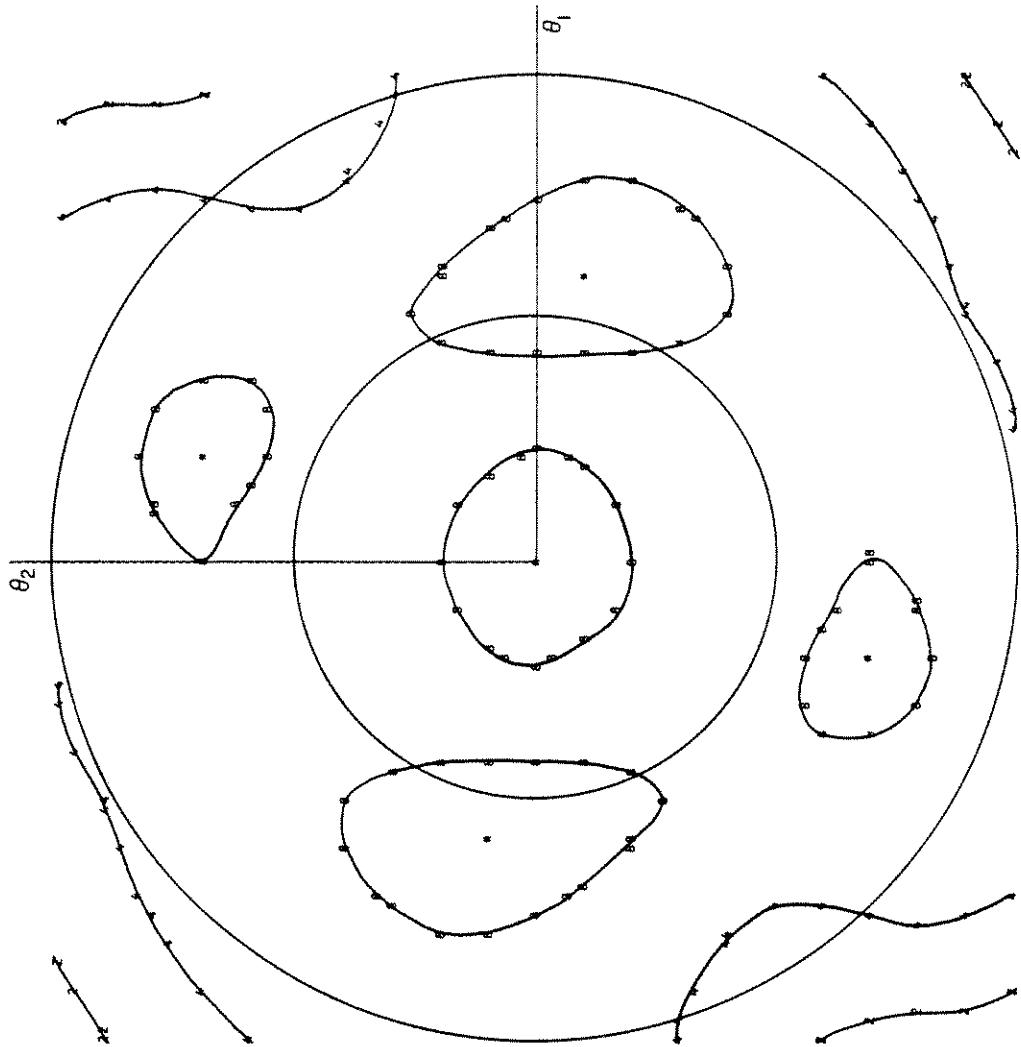


Figure 9h:  $\phi = 60^\circ$ ,  $\delta = 210^\circ$ ,  $\lambda = 6943 \text{ \AA}$ .

## 8. RANGE CORRECTION

Range corrections corresponding to the reflectivity data from Section 7 are given here; the data have been computed under the same conditions and are presented in the same format. The range correction is the difference between the centroid of the actual return pulse and the centroid of the pulse that would be received from a point reflector at the center of gravity of the satellite. In addition to the data on the centroid of the return, some information is presented on the half-maximum and half-area points of the return signal.

The data in this section have been computed for the incoherent case; the effect of coherent interference is discussed in Section 9. Note that the half-maximum and half-area data are not necessarily the average of the coherent cases.

Tables 8 and 9 were computed from the reflectivity curves of Figure 7. Table 8 gives the centroid of the total reflected signal, a quantity that can be measured only in the laboratory, where it is possible to collect the total reflected energy. Table 9 shows the average range correction in the annulus determined by the velocity aberration; the curves for the two wavelengths 5300 and 6943 Å are nearly identical, the maximum difference being about 1 mm. The difference in the curves between Table 8 and Table 9 is larger, with a maximum difference of about 1 cm. The range correction is plotted against the incidence angle  $\phi$  out to the largest angle at which the array is reflective. Only angles up to about  $60^\circ$  can actually be observed, as the satellite is gravity stabilized. The computer graph to the right of each page is plotted with the incidence angle increasing down the page and the range correction increasing to the right at a scale of 1 cm per horizontal print position. The horizontal origin of the graph has been displaced on each page to try to keep the points from going off scale.

The difference between the range correction for a half-maximum detection system and the range correction for a centroid detection system is shown in Table 10. The correction from this table, added to that from Table 9, yields the total range correction for this type of pulse detection. The largest values in the table are for the

shortest transmitted pulses. In Table 11, the difference between the range correction for a half-area detection system and that for a centroid detection system is given. The difference is largest for a 0.2-nsec pulse and is zero to within the accuracy of the computation for a 20-nsec pulse.

Table 12 shows how the range correction varies with velocity aberration. The format is the same as that of Table 6 for the gain function. The computer graphs on the right are plotted at a scale of 1 cm per horizontal print position. The horizontal origin of the range correction has been adjusted to keep the maximum in the same position on each page, while that for the rms fluctuation has not been adjusted. For  $\phi = 0^\circ$ , the range correction is constant throughout the whole far-field pattern. At other incidence angles, such as  $\phi = 45^\circ$ , variations with velocity aberration are larger. Fortunately, the largest variations occur around 10  $\mu\text{rad}$ , which is not an observable value of velocity aberration. The variations in the 25- to 50- $\mu\text{rad}$  range are under 2 cm.

Some of the range-correction matrices from which the data of Table 12 were computed are given in Table 13, where the format is the same as that of the gain matrices (Table 7). The angles  $\theta_1$  and  $\theta_2$  are defined in Figure 8. The average range correction in the 25- to 50- $\mu\text{rad}$  annulus obtained from these matrices agrees with the range corrections of Table 9, which were computed with the reflectivity curve of Figure 7 to within 1 mm for  $\lambda = 6943 \text{ \AA}$  and 1.5 mm for  $\lambda = 5300 \text{ \AA}$ .

Figure 11 consists of 1-cm-interval contour plots of the range-correction matrices in Table 13. No plots are given for  $\phi = 0^\circ$ , since the range correction is constant for this case. For other values of  $\phi$ , the range correction is asymmetric from left to right, just as the gain function was. As discussed in Section 7, the asymmetry is due to the method of orienting the cube corners.

Table 8. Centroid range correction for total reflected energy vs. incidence angle. (This quantity can be observed only under laboratory conditions, where it is possible to collect all the reflected energy.)

PHI (DEG)	RANGE CORRECTION (METERS)
0.0	1.3043
1.0	1.3046
2.0	1.3057
3.0	1.3074
4.0	1.3098
5.0	1.3126
6.0	1.3160
7.0	1.3198
8.0	1.3238
9.0	1.3281
10.0	1.3324
11.0	1.3368
12.0	1.3410
13.0	1.3450
14.0	1.3489
15.0	1.3524
16.0	1.3557
17.0	1.3586
18.0	1.3612
19.0	1.3629
20.0	1.3639
21.0	1.3645
22.0	1.3646
23.0	1.3643
24.0	1.3637
25.0	1.3627
26.0	1.3614
27.0	1.3597
28.0	1.3576
29.0	1.3550
30.0	1.3520
31.0	1.3486
32.0	1.3448
33.0	1.3405
34.0	1.3359
35.0	1.3308
36.0	1.3253
37.0	1.3194
38.0	1.3131
39.0	1.3064
40.0	1.2993
41.0	1.2917
42.0	1.2837
43.0	1.2752
44.0	1.2663
45.0	1.2569
46.0	1.2471
47.0	1.2369
48.0	1.2262
49.0	1.2152
50.0	1.2038
51.0	1.1920
52.0	1.1799
53.0	1.1675
54.0	1.1547
55.0	1.1416

Table 8. (Cont.)

PHI (DEG)	RANGE CORRECTION (METERS)
56.0	1.1281
57.0	1.1143
58.0	1.1002
59.0	1.0857
60.0	1.0710
61.0	1.0560
62.0	1.0407
63.0	1.0252
64.0	1.0094
65.0	*0.9933
66.0	*0.9771
67.0	*0.9606
68.0	*0.9438
69.0	*0.9266
70.0	*0.9091
71.0	*0.8913
72.0	*0.8732
73.0	*0.8548
74.0	*0.8361
75.0	*0.8170
76.0	*0.7977
77.0	*0.7781
78.0	*0.7583
79.0	*0.7382
80.0	*0.7178
81.0	*0.6973
82.0	*0.6765
83.0	*0.6555
84.0	*0.6343
85.0	*0.6130
86.0	*0.5916
87.0	*0.5700
88.0	*0.5484
89.0	*0.5268
90.0	*0.5053
91.0	*0.4839
92.0	*0.4629
93.0	*0.4424
94.0	*0.4216
95.0	*0.4002
96.0	*0.3788
97.0	*0.3568
98.0	*0.3343
99.0	*0.3122
100.0	*0.2892
101.0	*0.2651
102.0	*0.2415
103.0	*0.2187
104.0	*0.1952
105.0	*0.1694
106.0	*0.1430
107.0	*0.1185
108.0	*0.0984
109.0	*0.0840
110.0	*0.0740
111.0	*0.0491

Table 9. Average centroid range correction in the 25- to 50-μrad annulus of the far-field pattern vs. incidence angle. a:  $\lambda = 5300 \text{ Å}$ .

PHI (DEG)	RANGE CORRECTION (METERS)
0.0	1.3041
1.0	1.3045
2.0	1.3056
3.0	1.3074
4.0	1.3099
5.0	1.3131
6.0	1.3173
7.0	1.3221
8.0	1.3271
9.0	1.3322
10.0	1.3374
11.0	1.3426
12.0	1.3474
13.0	1.3519
14.0	1.3560
15.0	1.3598
16.0	1.3629
17.0	1.3655
18.0	1.3675
19.0	1.3690
20.0	1.3700
21.0	1.3706
22.0	1.3710
23.0	1.3711
24.0	1.3708
25.0	1.3700
26.0	1.3668
27.0	1.3642
28.0	1.3633
29.0	1.3630
30.0	1.3603
31.0	1.3571
32.0	1.3535
33.0	1.3495
34.0	1.3451
35.0	1.3401
36.0	1.3347
37.0	1.3289
38.0	1.3227
39.0	1.3162
40.0	1.3092
41.0	1.3016
42.0	1.2936
43.0	1.2851
44.0	1.2762
45.0	1.2669
46.0	1.2571
47.0	1.2468
48.0	1.2361
49.0	1.2249
50.0	1.2134
51.0	1.2014
52.0	1.1891
53.0	1.1764
54.0	1.1633
55.0	1.1499

Table 9a. (Cont.)

PHI (DEG)	RANGE CORRECTION (METERS)
56.0	1.1362
57.0	1.1221
58.0	1.1077
59.0	1.0931
60.0	1.0782
61.0	1.0631
62.0	1.0477
63.0	1.0322
64.0	1.0164
65.0	1.0004
66.0	*9841
67.0	*9677
68.0	*9509
69.0	*9338
70.0	*9164
71.0	*8985
72.0	*8801
73.0	*8614
74.0	*8424
75.0	*8230
76.0	*8034
77.0	*7833
78.0	*7629
79.0	*7421
80.0	*7213
81.0	*7005
82.0	*6796
83.0	*6585
84.0	*6370
85.0	*6155
86.0	*5943
87.0	*5731
88.0	*5518
89.0	*5306
90.0	*5090
91.0	*4876
92.0	*4661
93.0	*4444
94.0	*4229
95.0	*4008
96.0	*3790
97.0	*3571
98.0	*3358
99.0	*3110
100.0	*2869
101.0	*2636
102.0	*2407
103.0	*2170
104.0	*1943
105.0	*1688
106.0	*1440
107.0	*1191
108.0	*0944
109.0	*0704

Table 9b:  $\lambda = 6943 \text{ \AA}$ .

PHI (DEG)	RANGE CORRECTION (METERS)
0.0	1.3043
1.0	1.3047
2.0	1.3059
3.0	1.3080
4.0	1.3108
5.0	1.3145
6.0	1.3186
7.0	1.3231
8.0	1.3279
9.0	1.3328
10.0	1.3380
11.0	1.3431
12.0	1.3478
13.0	1.3523
14.0	1.3563
15.0	1.3599
16.0	1.3630
17.0	1.3656
18.0	1.3676
19.0	1.3691
20.0	1.3701
21.0	1.3707
22.0	1.3713
23.0	1.3716
24.0	1.3715
25.0	1.3709
26.0	1.3699
27.0	1.3684
28.0	1.3666
29.0	1.3643
30.0	1.3616
31.0	1.3585
32.0	1.3549
33.0	1.3508
34.0	1.3462
35.0	1.3411
36.0	1.3356
37.0	1.3297
38.0	1.3235
39.0	1.3168
40.0	1.3097
41.0	1.3022
42.0	1.2942
43.0	1.2858
44.0	1.2769
45.0	1.2676
46.0	1.2577
47.0	1.2473
48.0	1.2365
49.0	1.2253
50.0	1.2137
51.0	1.2017
52.0	1.1894
53.0	1.1767
54.0	1.1637
55.0	1.1504

Table 9b. (Cont.)

PHI (DEG)	RANGE CORRECTION (METERS)
56.0	1.1368
57.0	1.1229
58.0	1.1088
59.0	1.0943
60.0	1.0796
61.0	1.0646
62.0	1.0494
63.0	1.0338
64.0	1.0180
65.0	1.0019
66.0	*9854
67.0	*9686
68.0	*9515
69.0	*9340
70.0	*9161
71.0	*8979
72.0	*8792
73.0	*8602
74.0	*8410
75.0	*8215
76.0	*8021
77.0	*7823
78.0	*7623
79.0	*7419
80.0	*7214
81.0	*7011
82.0	*6805
83.0	*6599
84.0	*6390
85.0	*6179
86.0	*5969
87.0	*5758
88.0	*5546
89.0	*5334
90.0	*5119
91.0	*4906
92.0	*4690
93.0	*4472
94.0	*4254
95.0	*4030
96.0	*3811
97.0	*3590
98.0	*3376
99.0	*3125
100.0	*2879
101.0	*2644
102.0	*2411
103.0	*2174
104.0	*1948
105.0	*1694
106.0	*1446
107.0	*1197
108.0	*0949
109.0	*0707

Table 10. Difference between half-maximum and centroid range correction vs. incidence angle. The half-maximum range correction is the sum of Tables 9 and 10.

•2 NANOSECOND PULSE

PHI (DEG)	1/2 MAX. CORRECTION (METERS)
-----------	------------------------------

0.0	.0177 *
2.0	.0198 *
4.0	.0325 *
6.0	.0407 *
8.0	.0443 *
10.0	.0450 *
20.0	.0427 *
30.0	.0395 *
40.0	.0361 *
50.0	.0369 *
60.0	.0393 *
70.0	.0355 *
80.0	.0351 *
90.0	.0292 *
100.0	.0248 *

5 NANOSECOND PULSE

PHI (DEG)	1/2 MAX. CORRECTION (METERS)
-----------	------------------------------

0.0	.0006 *
10.0	.0051 *
20.0	.0059 *
30.0	.0062 *
40.0	.0059 *
50.0	.0063 *
60.0	.0061 *
70.0	.0046 *
80.0	.0035 *
90.0	.0020 *
100.0	.0010 *

20 NANOSECOND PULSE

PHI (DEG)	1/2 MAX. CORRECTION (METERS)
-----------	------------------------------

0.0	.0001 *
10.0	.0012 *
20.0	.0014 *
30.0	.0014 *
40.0	.0014 *
50.0	.0015 *
60.0	.0014 *
70.0	.0011 *
80.0	.0008 *
90.0	.0005 *
100.0	.0002 *

Table 11. Difference between half-area and centroid range correction vs. incidence angle. The half-area range correction is the sum of Tables 9 and 11.

.2 NANOSECOND PULSE

PHI (DEG) 1/2 AREA CORRECTION (METERS)

0.0	0.0000 *
2.0	.0003 *
4.0	.0026 *
6.0	.0076 *
8.0	.0118 *
10.0	.0137 *
20.0	.0172 *
30.0	.0182 *
40.0	.0181 *
50.0	.0191 *
60.0	.0180 *
70.0	.0135 *
80.0	.0090 *
90.0	.0035 *
100.0	0.0000 *

5 NANOSECOND PULSE

PHI (DEG) 1/2 AREA CORRECTION (METERS)

0.0	0.0000 *
10.0	.0002 *
20.0	.0004 *
30.0	.0005 *
40.0	.0005 *
50.0	.0005 *
60.0	.0005 *
70.0	.0003 *
80.0	.0001 *
90.0	.0001 *
100.0	0.0000 *

20 NANOSECOND PULSE

PHI (DEG) 1/2 AREA CORRECTION (METERS)

0.0	0.0000 *
10.0	-.0001 *
20.0	-.0001 *
30.0	-.0001 *
40.0	-.0001 *
50.0	-.0001 *
60.0	-.0001 *
70.0	-.0001 *
80.0	-.0001 *
90.0	-.0001 *
100.0	-.0001 *

Table 12. Centroid range correction vs. velocity aberration. The average and rms fluctuations are computed around a circle in the far field whose radius is the velocity aberration listed, in microradians, in the first column.

a: PHI 0 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300			b: PHI 5 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300			c: PHI 10 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300			d: PHI 15 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300			AVERAGE RANGE CORRECTION (METERS)									
AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)									
0 1.3041	5 1.3041	10 1.3041	15 1.3041	20 1.3041	25 1.3041	30 1.3041	35 1.3041	40 1.3041	45 1.3041	50 1.3041	*	0 1.3125	5 1.3126	10 1.3128	15 1.3131	20 1.3132	25 1.3131				
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
0 1.3041	5 1.3041	10 1.3041	15 1.3041	20 1.3041	25 1.3041	30 1.3041	35 1.3041	40 1.3041	45 1.3041	50 1.3041	*	0 1.3125	5 1.3126	10 1.3128	15 1.3131	20 1.3132	25 1.3131				
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
0 0.0000 *	5 0.0000 *	10 0.0000 *	15 0.0000 *	20 0.0000 *	25 0.0000 *	30 0.0000 *	35 0.0000 *	40 0.0000 *	45 0.0000 *	50 0.0000 *	0 0.0000 *	5 0.0002 *	10 0.0010 *	15 0.0021 *	20 0.0033 *	25 0.0044 *	30 0.0050 *				
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
0 1.3342	5 1.3345	10 1.3350	15 1.3352	20 1.3349	25 1.3346	30 1.3351	35 1.3367	40 1.3386	45 1.3399	50 1.3400	*	0 1.3557	5 1.3561	10 1.3565	15 1.3564	20 1.3565	25 1.3573	30 1.3593			
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
0 0.0000 *	5 0.0007 *	10 0.030 *	15 0.059 *	20 0.084 *	25 0.097 *	30 0.101 *	35 0.098 *	40 0.094 *	45 0.091 *	50 0.093 *	0 0.0000 *	5 0.0014 *	10 0.0054 *	15 0.0092 *	20 0.0107 *	25 0.0107 *	30 0.0108 *	35 0.0108 *	40 0.0112 *	45 0.0112 *	50 0.0122 *
*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		

Table 12. (Cont.)

e:	PHI	20	DIHEDRAL ANGLE	2.00	WAVELENGTH	5300	f:	PHI	25	DIHEDRAL ANGLE	2.00	WAVELENGTH	5300
AVERAGE RANGE CORRECTION (METERS)													
0	1.3614						0	1.3576					
5	1.3609	*					5	1.3517					
10	1.3606	*	*				10	1.3444					
15	1.3631	*	*	*			15	1.3557					
20	1.3664	*	*	*	*		20	1.3650					
25	1.3685	*	*	*	*		25	1.3687					
30	1.3707	*	*	*	*		30	1.3703					
35	1.3727	*	*	*	*		35	1.3709					
40	1.3730	*	*	*	*		40	1.3712					
45	1.3716	*	*	*	*		45	1.3712					
50	1.3694	*	*	*	*		50	1.3707					
R.M.S. FLUCTUATION													
0	0.0000	*					0	0.0000	*				
5	0.0020	*					5	0.0025	*				
10	0.0081	*					10	0.0041	*				
15	0.0117	*					15	0.0107	*				
20	0.0114	*					20	0.0160	*				
25	0.0109	*					25	0.0099	*				
30	0.0117	*					30	0.0118	*				
35	0.0126	*					35	0.0137	*				
40	0.0128	*					40	0.0134	*				
45	0.0129	*					45	0.0114	*				
50	0.0130	*					50	0.0099	*				
AVERAGE RANGE CORRECTION (METERS)													
0	1.3451	*					0	1.3227	*				
5	1.3316	*					5	1.3030	*				
10	1.3154	*					10	1.2722	*				
15	1.3333	*					15	1.2986	*				
20	1.3514	*					20	1.3249	*				
25	1.3573	*					25	1.3328	*				
30	1.3587	*					30	1.3364	*				
35	1.3600	*					35	1.3407	*				
40	1.3619	*					40	1.3437	*				
45	1.3628	*					45	1.3436	*				
50	1.3622	*					50	1.3418	*				
R.M.S. FLUCTUATION													
0	0.0000	*					0	0.0000	*				
5	0.0031	*					5	0.0033	*				
10	0.0068	*					10	0.0130	*				
15	0.0051	*					15	0.0039	*				
20	0.0074	*					20	0.0067	*				
25	0.0080	*					25	0.0071	*				
30	0.0101	*					30	0.0072	*				
35	0.0114	*					35	0.0070	*				
40	0.0102	*					40	0.0064	*				
45	0.0083	*					45	0.0063	*				
50	0.0073	*					50	0.0064	*				

Table 12. (Cont.)

AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)					
I: PHI 40 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300						J: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300					
R.M.S. FLUCTUATION						R.M.S. FLUCTUATION					
0	1.2226	* * *	* * *	* * *	* * *	0	1.2510	* * *	* * *	* * *	* * *
5	1.2694	* * *	* * *	* * *	* * *	5	1.2347	* * *	* * *	* * *	* * *
10	1.2275	* * *	* * *	* * *	* * *	10	1.1811	* * *	* * *	* * *	* * *
15	1.2885	* * *	* * *	* * *	* * *	15	1.2113	* * *	* * *	* * *	* * *
20	1.2871	* * *	* * *	* * *	* * *	20	1.2424	* * *	* * *	* * *	* * *
25	1.2962	* * *	* * *	* * *	* * *	25	1.2509	* * *	* * *	* * *	* * *
30	1.3037	* * *	* * *	* * *	* * *	30	1.2999	* * *	* * *	* * *	* * *
35	1.3105	* * *	* * *	* * *	* * *	35	1.2683	* * *	* * *	* * *	* * *
40	1.3132	* * *	* * *	* * *	* * *	40	1.2708	* * *	* * *	* * *	* * *
45	1.3126	* * *	* * *	* * *	* * *	45	1.2699	* * *	* * *	* * *	* * *
50	1.3115	* * *	* * *	* * *	* * *	50	1.2694	* * *	* * *	* * *	* * *
R.M.S. FLUCTUATION						R.M.S. FLUCTUATION					
0	0.0000	*	*	*	*	0	0.0000	*	*	*	*
5	*.0032	*	*	*	*	5	*.0031	*	*	*	*
10	*.072	*	*	*	*	10	*.038	*	*	*	*
15	*.0049	*	*	*	*	15	*.0076	*	*	*	*
20	*.0076	*	*	*	*	20	*.0082	*	*	*	*
25	*.0072	*	*	*	*	25	*.0082	*	*	*	*
30	*.0059	*	*	*	*	30	*.0066	*	*	*	*
35	*.0050	*	*	*	*	35	*.0051	*	*	*	*
40	*.0051	*	*	*	*	40	*.0052	*	*	*	*
45	*.0055	*	*	*	*	45	*.0056	*	*	*	*
50	*.0055	*	*	*	*	50	*.0060	*	*	*	*
AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)					
k: PHI 50 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300						l: PHI 55 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300					
R.M.S. FLUCTUATION						R.M.S. FLUCTUATION					
0	1.2048	* * *	* * *	* * *	* * *	0	1.1412	* * *	* * *	* * *	* * *
5	1.1853	* * *	* * *	* * *	* * *	5	1.1249	* * *	* * *	* * *	* * *
10	1.1417	* * *	* * *	* * *	* * *	10	1.0985	* * *	* * *	* * *	* * *
15	1.1694	* * *	* * *	* * *	* * *	15	1.1196	* * *	* * *	* * *	* * *
20	1.1937	* * *	* * *	* * *	* * *	20	1.1365	* * *	* * *	* * *	* * *
25	1.1992	* * *	* * *	* * *	* * *	25	1.1398	* * *	* * *	* * *	* * *
30	1.2058	* * *	* * *	* * *	* * *	30	1.1430	* * *	* * *	* * *	* * *
35	1.2141	* * *	* * *	* * *	* * *	35	1.1490	* * *	* * *	* * *	* * *
40	1.2173	* * *	* * *	* * *	* * *	40	1.1530	* * *	* * *	* * *	* * *
45	1.2163	* * *	* * *	* * *	* * *	45	1.1532	* * *	* * *	* * *	* * *
50	1.2149	* * *	* * *	* * *	* * *	50	1.1512	* * *	* * *	* * *	* * *
R.M.S. FLUCTUATION						R.M.S. FLUCTUATION					
0	0.0000	*	*	*	*	0	0.0000	*	*	*	*
5	*.0026	*	*	*	*	5	*.0026	*	*	*	*
10	*.0076	*	*	*	*	10	*.0065	*	*	*	*
15	*.0053	*	*	*	*	15	*.0069	*	*	*	*
20	*.0082	*	*	*	*	20	*.0082	*	*	*	*
25	*.0086	*	*	*	*	25	*.0088	*	*	*	*
30	*.0083	*	*	*	*	30	*.0095	*	*	*	*
35	*.0066	*	*	*	*	35	*.0086	*	*	*	*
40	*.0057	*	*	*	*	40	*.0068	*	*	*	*
45	*.0060	*	*	*	*	45	*.0068	*	*	*	*
50	*.0066	*	*	*	*	50	*.0080	*	*	*	*

Table 12. (Cont.)

m:	PHI	60	DIHEDRAL ANGLE	2.00	WAVELENGTH	5300	n:	PHI	0	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943
AVERAGE RANGE CORRECTION (METERS)													
0	1.0662					*	0	1.2043					
5	1.0662	*	*	*	*	*	5	1.2043	*	*	*	*	*
10	1.0425	*	*	*	*	*	10	1.2043	*	*	*	*	*
15	1.0553	*	*	*	*	*	15	1.2043	*	*	*	*	*
20	1.0590	*	*	*	*	*	20	1.2043	*	*	*	*	*
25	1.0728	*	*	*	*	*	25	1.2043	*	*	*	*	*
30	1.0737	*	*	*	*	*	30	1.2043	*	*	*	*	*
35	1.0759	*	*	*	*	*	35	1.2043	*	*	*	*	*
40	1.0785	*	*	*	*	*	40	1.2043	*	*	*	*	*
45	1.0796	*	*	*	*	*	45	1.2043	*	*	*	*	*
50	1.0788	*	*	*	*	*	50	1.2043	*	*	*	*	*
R.M.S. FLUCTUATION													
0	0.0000	*					0	0.0000	*				
5	*.0028	*					5	*.0000	*				
10	*.0010	*					10	*.0000	*				
15	*.0008	*					15	*.0000	*				
20	*.0082	*					20	*.0000	*				
25	*.0084	*					25	*.0000	*				
30	*.0094	*					30	*.0000	*				
35	*.0097	*					35	*.0000	*				
40	*.0098	*					40	*.0000	*				
45	*.0094	*					45	*.0000	*				
50	*.0101	*					50	*.0000	*				
AVERAGE RANGE CORRECTION (METERS)													
0	1.3174					*	*	0	1.3437				
5	1.3173					*	5	1.3436					
10	1.3171					*	10	1.3436					
15	1.3167					*	15	1.3431					
20	1.3166					*	20	1.3425					
25	1.3159					*	25	1.3417					
30	1.3155					*	30	1.3404					
35	1.3149					*	35	1.3389					
40	1.3141					*	40	1.3376					
45	1.3132					*	45	1.3367					
50	1.3123					*	50	1.3363					
R.M.S. FLUCTUATION													
0	0.0000	*					0	0.0000	*				
5	*.0000	*					5	*.0001	*				
10	*.0002	*					10	*.0006	*				
15	*.0004	*					15	*.0015	*				
20	*.0009	*					20	*.0028	*				
25	*.0015	*					25	*.0044	*				
30	*.0022	*					30	*.0059	*				
35	*.0030	*					35	*.0071	*				
40	*.0037	*					40	*.0076	*				
45	*.0041	*					45	*.0076	*				
50	*.0043	*					50	*.0076	*				
AVERAGE RANGE CORRECTION (METERS)													
0	1.2043					*	*	0	1.2043				
5	1.2043					*	5	1.2043					
10	1.2043					*	10	1.2043					
15	1.2043					*	15	1.2043					
20	1.2043					*	20	1.2043					
25	1.2043					*	25	1.2043					
30	1.2043					*	30	1.2043					
35	1.2043					*	35	1.2043					
40	1.2043					*	40	1.2043					
45	1.2043					*	45	1.2043					
50	1.2043					*	50	1.2043					
R.M.S. FLUCTUATION													

Table 12. (Cont.)

AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)								
q:	PHI	15	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	r:	PHI	20	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	t:	PHI	30	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943
0	1.3655						0	1.3746						0	1.3585					
5	1.3654	*	*	*	*	*	5	1.3742	*	*	*	*	*	5	1.3556	*	*	*	*	*
10	1.3652	*	*	*	*	*	10	1.3733	*	*	*	*	*	10	1.3442	*	*	*	*	*
15	1.3648	*	*	*	*	*	15	1.3720	*	*	*	*	*	15	1.3485	*	*	*	*	*
20	1.3639	*	*	*	*	*	20	1.3707	*	*	*	*	*	20	1.3627	*	*	*	*	*
25	1.3625	*	*	*	*	*	25	1.3702	*	*	*	*	*	25	1.3640	*	*	*	*	*
30	1.3612	*	*	*	*	*	30	1.3705	*	*	*	*	*	30	1.3650	*	*	*	*	*
35	1.3603	*	*	*	*	*	35	1.3707	*	*	*	*	*	35	1.3655	*	*	*	*	*
40	1.3600	*	*	*	*	*	40	1.3709	*	*	*	*	*	40	1.3661	*	*	*	*	*
45	1.3602	*	*	*	*	*	45	1.3713	*	*	*	*	*	45	1.3666	*	*	*	*	*
50	1.3608	*	*	*	*	*	50	1.3715	*	*	*	*	*	50	1.3666	*	*	*	*	*
R.M.S. FLUCTUATION						R.M.S. FLUCTUATION						R.M.S. FLUCTUATION								
0	0.0000	*	*	*	*	*	0	0.0000	*	*	*	*	*	0	1.3585	*	*	*	*	*
5	*.0002	*	*	*	*	*	5	*.0003	*	*	*	*	*	5	*.0013	*	*	*	*	*
10	*.0011	*	*	*	*	*	10	*.0013	*	*	*	*	*	10	*.0037	*	*	*	*	*
15	*.0027	*	*	*	*	*	15	*.0037	*	*	*	*	*	15	*.0075	*	*	*	*	*
20	*.0052	*	*	*	*	*	20	*.0101	*	*	*	*	*	20	*.0102	*	*	*	*	*
25	*.0075	*	*	*	*	*	25	*.0102	*	*	*	*	*	25	*.0091	*	*	*	*	*
30	*.0088	*	*	*	*	*	30	*.0091	*	*	*	*	*	30	*.0082	*	*	*	*	*
35	*.0087	*	*	*	*	*	35	*.0082	*	*	*	*	*	35	*.0086	*	*	*	*	*
40	*.0081	*	*	*	*	*	40							40						
45	*.0077	*	*	*	*	*	45							45						
50	*.0077	*	*	*	*	*	50							50						
AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)								
0	1.3723	*	*	*	*	*	0	1.3585	*	*	*	*	*	0	1.3585	*	*	*	*	*
5	1.3709	*	*	*	*	*	5	1.3556	*	*	*	*	*	5	1.3442	*	*	*	*	*
10	1.3679	*	*	*	*	*	10	1.3493	*	*	*	*	*	10	1.3442	*	*	*	*	*
15	1.3667	*	*	*	*	*	15	1.3442	*	*	*	*	*	15	1.3485	*	*	*	*	*
20	1.3647	*	*	*	*	*	20	1.3485	*	*	*	*	*	20	1.3573	*	*	*	*	*
25	1.3633	*	*	*	*	*	25	1.3573	*	*	*	*	*	25	1.3627	*	*	*	*	*
30	1.3714	*	*	*	*	*	30	1.3627	*	*	*	*	*	30	1.3640	*	*	*	*	*
35	1.3724	*	*	*	*	*	35	1.3640	*	*	*	*	*	35	1.3650	*	*	*	*	*
40	1.3721	*	*	*	*	*	40	1.3650	*	*	*	*	*	40	1.3613	*	*	*	*	*
45	1.3713	*	*	*	*	*	45	1.3613	*	*	*	*	*	45	1.3600	*	*	*	*	*
50	1.3701	*	*	*	*	*	50	1.3600	*	*	*	*	*	50						
R.M.S. FLUCTUATION						R.M.S. FLUCTUATION						R.M.S. FLUCTUATION								
0	0.0000	*	*	*	*	*	0	0.0000	*	*	*	*	*	0	0.0000	*	*	*	*	*
5	*.0004	*	*	*	*	*	5	*.0005	*	*	*	*	*	5	*.0022	*	*	*	*	*
10	*.0018	*	*	*	*	*	10	*.0022	*	*	*	*	*	10	*.0053	*	*	*	*	*
15	*.0050	*	*	*	*	*	15	*.0053	*	*	*	*	*	15	*.0067	*	*	*	*	*
20	*.0085	*	*	*	*	*	20	*.0067	*	*	*	*	*	20	*.0067	*	*	*	*	*
25	*.0095	*	*	*	*	*	25	*.0067	*	*	*	*	*	25	*.0067	*	*	*	*	*
30	*.0068	*	*	*	*	*	30	*.0060	*	*	*	*	*	30	*.0060	*	*	*	*	*
35	*.0078	*	*	*	*	*	35	*.0055	*	*	*	*	*	35	*.0061	*	*	*	*	*
40	*.0076	*	*	*	*	*	40	*.0061	*	*	*	*	*	40	*.0078	*	*	*	*	*
45	*.0087	*	*	*	*	*	45	*.0078	*	*	*	*	*	45	*.0086	*	*	*	*	*
50	*.0100	*	*	*	*	*	50							50						

Table 12. (Cont.)

u:	phi	35	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	v:	phi	40	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	AVERAGE RANGE CORRECTION (METERS)			
														v:	phi	40	
0	1.3335						0	1.2980						0	1.2914		
5	1.3287						5	1.2914						5	1.2777		
10	1.3185						10	1.2777						10	1.2732		
15	1.3129						15	1.2732						15	1.2903		
20	1.3233						20	1.2903						20	1.3051		
25	1.3362						25	1.3051						25	1.3102		
30	1.3423						30	1.3102						30	1.3104		
35	1.3432						35	1.3104						35	1.3101		
40	1.3421						40	1.3101						40	1.3110		
45	1.3414						45	1.3110						45	1.3112		
50	1.3417						50	1.3112						50	1.3122		
																	R.M.S. FLUCTUATION
w:	phi	45	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	x:	phi	50	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943				AVERAGE RANGE CORRECTION (METERS)
0	1.2561						0	1.2042						0	1.1986		
5	1.2492						5	1.1986						5	1.1867		
10	1.2342						10	1.1867						10	1.1834		
15	1.2295						15	1.1834						15	1.1992		
20	1.2486						20	1.1992						20	1.2115		
25	1.2633						25	1.2115						25	1.2144		
30	1.2672						30	1.2144						30	1.2130		
35	1.2666						35	1.2130						35	1.2120		
40	1.2666						40	1.2120						40	1.2137		
45	1.2688						45	1.2137						45	1.2160		
50	1.2704						50	1.2160						50	1.2160		
																	R.M.S. FLUCTUATION
v:	phi	40	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943	x:	phi	50	DIHEDRAL ANGLE	2.00	WAVELENGTH	6943				AVERAGE RANGE CORRECTION (METERS)
0	0.0000	*					0	0.0000	*					0	0.0000	*	
5	0.0007	*					5	0.0007	*					5	0.0013	*	
10	0.014	*					10	0.014	*					10	0.029	*	
15	0.063	*					15	0.063	*					15	0.039	*	
20	0.031	*					20	0.031	*					20	0.056	*	
25	0.044	*					25	0.044	*					25	0.065	*	
30	0.060	*					30	0.060	*					30	0.071	*	
35	0.064	*					35	0.064	*					35	0.080	*	
40	0.072	*					40	0.072	*					40	0.088	*	
45	0.080	*					45	0.080	*					45	0.089	*	
50	0.078	*					50	0.078	*					50	0.089	*	
																	R.M.S. FLUCTUATION

Table 12. (Cont.)

Y: PHI 55		DIHEDRAL ANGLE 2.00		WAVELENGTH 6943		Z: PHI 60		DIHEDRAL ANGLE 2.00		WAVELENGTH 6943	
AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)					
0	1.1451	*	*	*	*	0	1.0785				
5	1.1411	*	*	*	*	5	1.0759				
10	1.1330	*	*	*	*	10	1.0702				
15	1.1296	*	*	*	*	15	1.0659				
20	1.1393	*	*	*	*	20	1.0692				
25	1.1490	*	*	*	*	25	1.0764				
30	1.1522	*	*	*	*	30	1.0807				
35	1.1510	*	*	*	*	35	1.0811				
40	1.1489	*	*	*	*	40	1.0793				
45	1.1485	*	*	*	*	45	1.0773				
50	1.1498	*	*	*	*	50	1.0764				
R.M.S. FLUCTUATION						R.M.S. FLUCTUATION					
0	0.0000	*	*	*	*	0	0.0000	*	*	*	*
5	.0008	*	*	*	*	5	.0007	*	*	*	*
10	.0025	*	*	*	*	10	.0028	*	*	*	*
15	.0051	*	*	*	*	15	.0063	*	*	*	*
20	.0063	*	*	*	*	20	.0086	*	*	*	*
25	.0063	*	*	*	*	25	.0077	*	*	*	*
30	.0064	*	*	*	*	30	.0066	*	*	*	*
35	.0071	*	*	*	*	35	.0069	*	*	*	*
40	.0085	*	*	*	*	40	.0084	*	*	*	*
45	.0099	*	*	*	*	45	.0102	*	*	*	*
50	.0104	*	*	*	*	50	.0116	*	*	*	*

Table 13. Sample centroid range-correction matrices. The angles  $\theta_1$  and  $\theta_2$ , in microradians, are defined in Figure 8. Only half the matrix is presented since the value for  $(\theta_1, \theta_2)$  equals that for  $(-\theta_1, -\theta_2)$ .

$\theta_2$	RANGE CORRECTION (METERS)											
	DIHEDRAL ANGLE 2.00 WAVELENGTH 5300											
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
45	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
40	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
35	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
30	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
25	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
20	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
15	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
10	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
5	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
0	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-5	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-10	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-15	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-20	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-25	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-30	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-35	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-40	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-45	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-50	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304

$\theta_2$	RANGE CORRECTION (METERS)											
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.362	1.362	1.362	1.362	1.363	1.364	1.367	1.368	1.369	1.369	1.368	1.368
45	1.360	1.360	1.360	1.361	1.363	1.365	1.368	1.371	1.373	1.373	1.372	1.372
40	1.357	1.357	1.358	1.359	1.362	1.366	1.370	1.373	1.376	1.377	1.377	1.377
35	1.357	1.355	1.356	1.358	1.362	1.367	1.371	1.375	1.377	1.380	1.381	1.381
30	1.357	1.355	1.355	1.358	1.364	1.370	1.374	1.377	1.379	1.382	1.384	1.384
25	1.356	1.353	1.355	1.360	1.367	1.373	1.377	1.380	1.382	1.384	1.385	1.385
20	1.350	1.349	1.355	1.364	1.371	1.377	1.382	1.385	1.386	1.386	1.386	1.386
15	1.337	1.343	1.356	1.368	1.375	1.381	1.386	1.390	1.391	1.390	1.388	1.388
10	1.333	1.345	1.359	1.371	1.379	1.384	1.390	1.394	1.395	1.393	1.389	1.389
5	1.351	1.355	1.360	1.371	1.379	1.384	1.391	1.396	1.396	1.393	1.389	1.389
0	1.358	1.355	1.356	1.368	1.377	1.382	1.389	1.394	1.394	1.390	1.386	1.386
-5	1.351	1.343	1.348	1.367	1.376	1.379	1.384	1.389	1.389	1.385	1.380	1.380
-10	1.333	1.331	1.352	1.369	1.374	1.375	1.379	1.382	1.381	1.377	1.373	1.373
-15	1.337	1.347	1.361	1.369	1.371	1.370	1.373	1.375	1.373	1.369	1.367	1.367
-20	1.350	1.357	1.364	1.367	1.367	1.366	1.368	1.369	1.366	1.363	1.362	1.362
-25	1.356	1.360	1.363	1.364	1.363	1.363	1.365	1.364	1.361	1.359	1.360	1.360
-30	1.357	1.360	1.360	1.359	1.359	1.362	1.364	1.363	1.359	1.358	1.357	1.357
-35	1.357	1.357	1.357	1.357	1.360	1.364	1.365	1.362	1.358	1.356	1.353	1.353
-40	1.357	1.357	1.358	1.360	1.364	1.367	1.367	1.363	1.358	1.355	1.350	1.350
-45	1.360	1.360	1.361	1.364	1.368	1.369	1.367	1.363	1.358	1.355	1.349	1.349
-50	1.362	1.363	1.365	1.367	1.369	1.369	1.367	1.363	1.359	1.355	1.350	1.350

Table 13. (Cont.)

c: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300

$\theta_2$	RANGE CORRECTION (METERS)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.270	1.267	1.266	1.264	1.263	1.262	1.258	1.250	1.239	1.228	1.222
45	1.269	1.267	1.265	1.263	1.262	1.261	1.260	1.255	1.246	1.237	1.231
40	1.268	1.266	1.264	1.262	1.260	1.258	1.258	1.256	1.252	1.246	1.242
35	1.262	1.262	1.264	1.265	1.263	1.260	1.257	1.257	1.256	1.254	1.253
30	1.250	1.254	1.261	1.265	1.266	1.263	1.261	1.261	1.261	1.260	1.260
25	1.240	1.245	1.253	1.259	1.261	1.264	1.267	1.268	1.266	1.265	
20	1.239	1.241	1.244	1.247	1.249	1.254	1.264	1.272	1.274	1.272	1.267
15	1.223	1.225	1.231	1.236	1.238	1.245	1.263	1.274	1.277	1.274	1.269
10	1.192	1.189	1.196	1.223	1.238	1.248	1.264	1.275	1.277	1.274	1.270
5	1.239	1.221	1.162	1.206	1.250	1.262	1.270	1.276	1.276	1.273	1.271
0	1.257	1.242	1.166	1.207	1.260	1.268	1.272	1.275	1.274	1.271	1.272
-5	1.239	1.218	1.139	1.227	1.260	1.265	1.268	1.272	1.272	1.271	1.273
-10	1.192	1.180	1.199	1.242	1.256	1.258	1.264	1.270	1.272	1.272	1.273
-15	1.223	1.226	1.237	1.248	1.253	1.258	1.266	1.273	1.275	1.273	1.271
-20	1.239	1.241	1.246	1.254	1.261	1.267	1.274	1.277	1.276	1.273	1.268
-25	1.240	1.243	1.253	1.266	1.273	1.276	1.277	1.278	1.275	1.270	1.266
-30	1.250	1.255	1.265	1.274	1.277	1.276	1.276	1.275	1.273	1.269	1.266
-35	1.262	1.266	1.271	1.275	1.275	1.273	1.273	1.274	1.273	1.270	1.267
-40	1.268	1.270	1.272	1.273	1.273	1.273	1.276	1.278	1.276	1.271	1.266
-45	1.269	1.271	1.273	1.274	1.276	1.279	1.281	1.280	1.276	1.268	1.262
-50	1.270	1.272	1.275	1.278	1.280	1.282	1.281	1.276	1.268	1.259	1.254

d: PHI 60 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300

$\theta_2$	RANGE CORRECTION (METERS)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.074	1.073	1.072	1.072	1.072	1.072	1.069	1.060	1.046	1.031	
45	1.069	1.069	1.071	1.073	1.075	1.075	1.074	1.070	1.063	1.053	1.041
40	1.062	1.065	1.070	1.075	1.078	1.078	1.076	1.072	1.065	1.058	1.051
35	1.059	1.065	1.072	1.076	1.078	1.079	1.077	1.072	1.066	1.060	1.056
30	1.062	1.070	1.075	1.078	1.078	1.077	1.076	1.072	1.065	1.060	1.057
25	1.066	1.074	1.079	1.078	1.075	1.073	1.073	1.071	1.065	1.058	1.056
20	1.062	1.072	1.077	1.077	1.071	1.067	1.068	1.070	1.066	1.060	1.056
15	1.043	1.056	1.067	1.071	1.068	1.063	1.066	1.072	1.072	1.067	1.062
10	1.035	1.031	1.047	1.064	1.068	1.066	1.070	1.078	1.080	1.077	1.071
5	1.059	1.042	1.036	1.061	1.072	1.074	1.079	1.086	1.087	1.083	1.078
0	1.068	1.058	1.046	1.066	1.078	1.082	1.086	1.091	1.091	1.087	1.083
-5	1.059	1.056	1.055	1.073	1.083	1.086	1.090	1.093	1.093	1.090	1.086
-10	1.035	1.040	1.057	1.075	1.083	1.066	1.090	1.092	1.093	1.091	1.088
-15	1.043	1.041	1.057	1.073	1.080	1.064	1.087	1.090	1.091	1.091	1.090
-20	1.062	1.054	1.057	1.068	1.077	1.081	1.084	1.087	1.090	1.091	1.091
-25	1.066	1.058	1.057	1.066	1.075	1.080	1.083	1.086	1.089	1.092	1.092
-30	1.062	1.057	1.060	1.069	1.078	1.083	1.085	1.088	1.090	1.092	1.092
-35	1.059	1.059	1.065	1.075	1.084	1.088	1.090	1.091	1.093	1.094	1.093
-40	1.062	1.065	1.071	1.080	1.088	1.092	1.093	1.095	1.096	1.095	1.094
-45	1.069	1.071	1.075	1.081	1.088	1.092	1.094	1.096	1.097	1.096	1.094
-50	1.074	1.074	1.074	1.078	1.083	1.087	1.090	1.094	1.096	1.096	1.093

0 5 10 15 20 25 30 35 40 45 50  $\theta_1$

Table 13. (Cont.)

e: PHI 0 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

 $\theta_2$ 

## RANGE CORRECTION (METERS)

50	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
45	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
40	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
35	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
30	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
25	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
20	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
15	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
10	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
5	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
0	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-5	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-10	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-15	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-20	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-25	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-30	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-35	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-40	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-45	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304
-50	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304	1.304

0      5      10      15      20      25      30      35      40      45      50      0<sub>1</sub>

f: PHI 25 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

 $\theta_2$ 

## RANGE CORRECTION (METERS)

50	1.361	1.360	1.359	1.361	1.363	1.365	1.368	1.370	1.370	1.371	1.370	1.370	1.370	1.370
45	1.361	1.360	1.360	1.362	1.364	1.367	1.369	1.371	1.372	1.372	1.372	1.372	1.372	1.370
40	1.361	1.360	1.361	1.364	1.367	1.369	1.371	1.373	1.374	1.373	1.371	1.371	1.371	1.371
35	1.359	1.359	1.361	1.365	1.369	1.372	1.374	1.376	1.376	1.376	1.374	1.374	1.374	1.374
30	1.356	1.357	1.362	1.367	1.372	1.376	1.377	1.378	1.379	1.379	1.377	1.377	1.377	1.377
25	1.351	1.355	1.362	1.370	1.375	1.379	1.380	1.381	1.382	1.382	1.381	1.381	1.381	1.381
20	1.351	1.357	1.365	1.372	1.378	1.381	1.383	1.383	1.384	1.385	1.384	1.384	1.384	1.384
15	1.359	1.363	1.368	1.373	1.379	1.382	1.383	1.384	1.385	1.387	1.387	1.387	1.387	1.387
10	1.367	1.369	1.370	1.373	1.377	1.381	1.382	1.383	1.385	1.387	1.389	1.389	1.389	1.389
5	1.371	1.371	1.370	1.371	1.375	1.379	1.380	1.381	1.383	1.386	1.388	1.388	1.388	1.388
0	1.372	1.371	1.369	1.369	1.372	1.377	1.379	1.379	1.380	1.384	1.386	1.386	1.386	1.386
-5	1.371	1.369	1.366	1.366	1.371	1.376	1.378	1.377	1.377	1.380	1.382	1.382	1.382	1.382
-10	1.367	1.364	1.361	1.364	1.371	1.377	1.377	1.376	1.375	1.376	1.377	1.377	1.377	1.377
-15	1.359	1.355	1.355	1.363	1.372	1.377	1.377	1.374	1.372	1.372	1.371	1.371	1.371	1.371
-20	1.351	1.349	1.355	1.365	1.372	1.375	1.374	1.371	1.368	1.367	1.365	1.365	1.365	1.365
-25	1.351	1.353	1.359	1.367	1.371	1.373	1.371	1.368	1.365	1.363	1.359	1.359	1.359	1.359
-30	1.356	1.358	1.363	1.367	1.370	1.370	1.367	1.364	1.362	1.359	1.355	1.355	1.355	1.355
-35	1.359	1.362	1.365	1.367	1.368	1.366	1.364	1.361	1.359	1.357	1.352	1.352	1.352	1.352
-40	1.361	1.363	1.365	1.366	1.365	1.363	1.361	1.360	1.359	1.357	1.352	1.352	1.352	1.352
-45	1.361	1.363	1.364	1.364	1.362	1.361	1.361	1.362	1.361	1.361	1.358	1.353	1.353	1.353
-50	1.361	1.362	1.362	1.362	1.361	1.361	1.362	1.364	1.364	1.361	1.355	1.355	1.355	1.355

0      5      10      15      20      25      30      35      40      45      50      0<sub>1</sub>

Table 13. (Cont.)

		DIHEDRAL ANGLE 2.00										WAVELENGTH 6943	
		RANGE CORRECTION (METERS)											
$\theta_2$		0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.266	1.266	1.267	1.269	1.270	1.268	1.263	1.257	1.250	1.243	1.237		
45	1.263	1.264	1.267	1.271	1.273	1.272	1.269	1.262	1.254	1.247	1.240		
40	1.260	1.261	1.265	1.269	1.272	1.272	1.270	1.264	1.258	1.251	1.244		
35	1.261	1.262	1.264	1.266	1.268	1.268	1.266	1.262	1.258	1.253	1.249		
30	1.264	1.263	1.263	1.263	1.263	1.262	1.260	1.257	1.255	1.254	1.253		
25	1.262	1.262	1.262	1.262	1.261	1.258	1.255	1.251	1.251	1.254	1.257		
20	1.253	1.253	1.255	1.258	1.260	1.259	1.256	1.252	1.252	1.257	1.262		
15	1.236	1.237	1.241	1.250	1.258	1.262	1.261	1.259	1.260	1.265	1.269		
10	1.236	1.233	1.227	1.235	1.253	1.265	1.269	1.269	1.271	1.275	1.277		
5	1.251	1.245	1.230	1.223	1.247	1.268	1.276	1.277	1.279	1.281	1.282		
0	1.256	1.251	1.233	1.218	1.246	1.271	1.279	1.281	1.282	1.283	1.283		
-5	1.251	1.245	1.228	1.220	1.252	1.274	1.279	1.280	1.279	1.280	1.280		
-10	1.236	1.231	1.224	1.237	1.262	1.274	1.276	1.275	1.274	1.274	1.275		
-15	1.236	1.237	1.243	1.256	1.267	1.272	1.271	1.268	1.267	1.268	1.269		
-20	1.253	1.255	1.259	1.264	1.268	1.268	1.266	1.263	1.262	1.265	1.267		
-25	1.262	1.263	1.264	1.266	1.267	1.267	1.265	1.264	1.264	1.267	1.267		
-30	1.264	1.264	1.265	1.266	1.268	1.270	1.270	1.270	1.270	1.270	1.269		
-35	1.261	1.262	1.264	1.269	1.273	1.276	1.277	1.276	1.274	1.271	1.268		
-40	1.260	1.262	1.267	1.273	1.279	1.281	1.281	1.278	1.274	1.269	1.264		
-45	1.263	1.265	1.271	1.277	1.281	1.282	1.280	1.275	1.270	1.264	1.260		
-50	1.266	1.269	1.273	1.276	1.278	1.278	1.275	1.269	1.264	1.261	1.258		

h: PHI 60 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

		DIHEDRAL ANGLE 2.00										WAVELENGTH 6943	
		RANGE CORRECTION (METERS)											
$\theta_2$		0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.059	1.062	1.068	1.074	1.078	1.081	1.081	1.080	1.076	1.068	1.055		
45	1.065	1.068	1.073	1.077	1.080	1.081	1.080	1.078	1.074	1.066	1.053		
40	1.070	1.074	1.077	1.080	1.081	1.080	1.078	1.075	1.071	1.063	1.050		
35	1.073	1.076	1.080	1.082	1.082	1.079	1.075	1.070	1.065	1.059	1.049		
30	1.073	1.075	1.079	1.081	1.081	1.077	1.071	1.065	1.060	1.056	1.050		
25	1.067	1.069	1.072	1.076	1.078	1.076	1.070	1.063	1.058	1.057	1.055		
20	1.059	1.057	1.062	1.069	1.074	1.075	1.072	1.065	1.061	1.061	1.063		
15	1.061	1.055	1.055	1.063	1.072	1.076	1.075	1.071	1.067	1.068	1.070		
10	1.070	1.064	1.058	1.062	1.071	1.078	1.079	1.076	1.074	1.075	1.077		
5	1.077	1.072	1.066	1.065	1.074	1.081	1.083	1.081	1.080	1.081	1.082		
0	1.078	1.076	1.071	1.070	1.077	1.084	1.086	1.085	1.084	1.085	1.086		
-5	1.077	1.076	1.073	1.074	1.081	1.087	1.089	1.089	1.088	1.089	1.090		
-10	1.070	1.072	1.073	1.078	1.085	1.090	1.092	1.091	1.091	1.091	1.091		
-15	1.061	1.066	1.072	1.080	1.087	1.092	1.093	1.092	1.092	1.092	1.092		
-20	1.059	1.065	1.073	1.081	1.088	1.092	1.093	1.092	1.091	1.091	1.092		
-25	1.067	1.069	1.075	1.081	1.087	1.090	1.091	1.090	1.090	1.090	1.090		
-30	1.073	1.072	1.075	1.080	1.084	1.088	1.089	1.089	1.089	1.088	1.089		
-35	1.073	1.072	1.073	1.076	1.081	1.085	1.088	1.089	1.088	1.087	1.087		
-40	1.070	1.068	1.069	1.072	1.078	1.084	1.088	1.090	1.089	1.088	1.087		
-45	1.065	1.063	1.064	1.069	1.076	1.084	1.090	1.092	1.092	1.090	1.087		
-50	1.059	1.058	1.061	1.067	1.076	1.085	1.092	1.095	1.094	1.092	1.088		

0 5 10 15 20 25 30 35 40 45 50  $\theta_1$

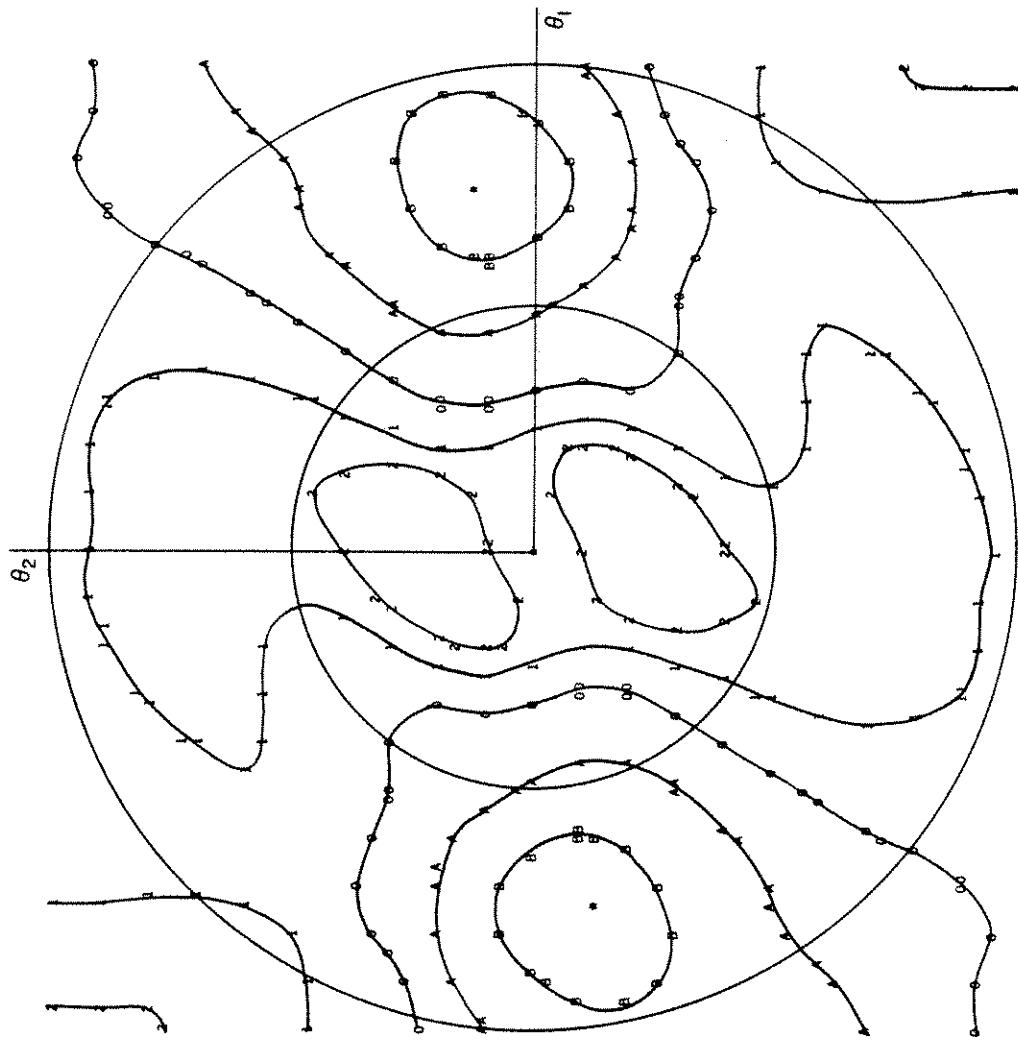


Figure 11. Contour plots of the centroid range-correction matrices given in Table 13. Circles of radius 25 and 50  $\mu$ rad are shown to mark the minimum and maximum values of the velocity aberration. On the plots, the symbol B indicates that the range correction minus the average range correction in the 25- to 50- $\mu$ rad annulus is equal to +2 cm; A equals +1 cm; 0 equals 0 cm; and 1 through 8 equal -1 through -8 cm. a:  $\phi = 25^\circ$ ,  $\delta = 21^\circ 0'$ ,  $\lambda = 5300 \text{ \AA}$ .

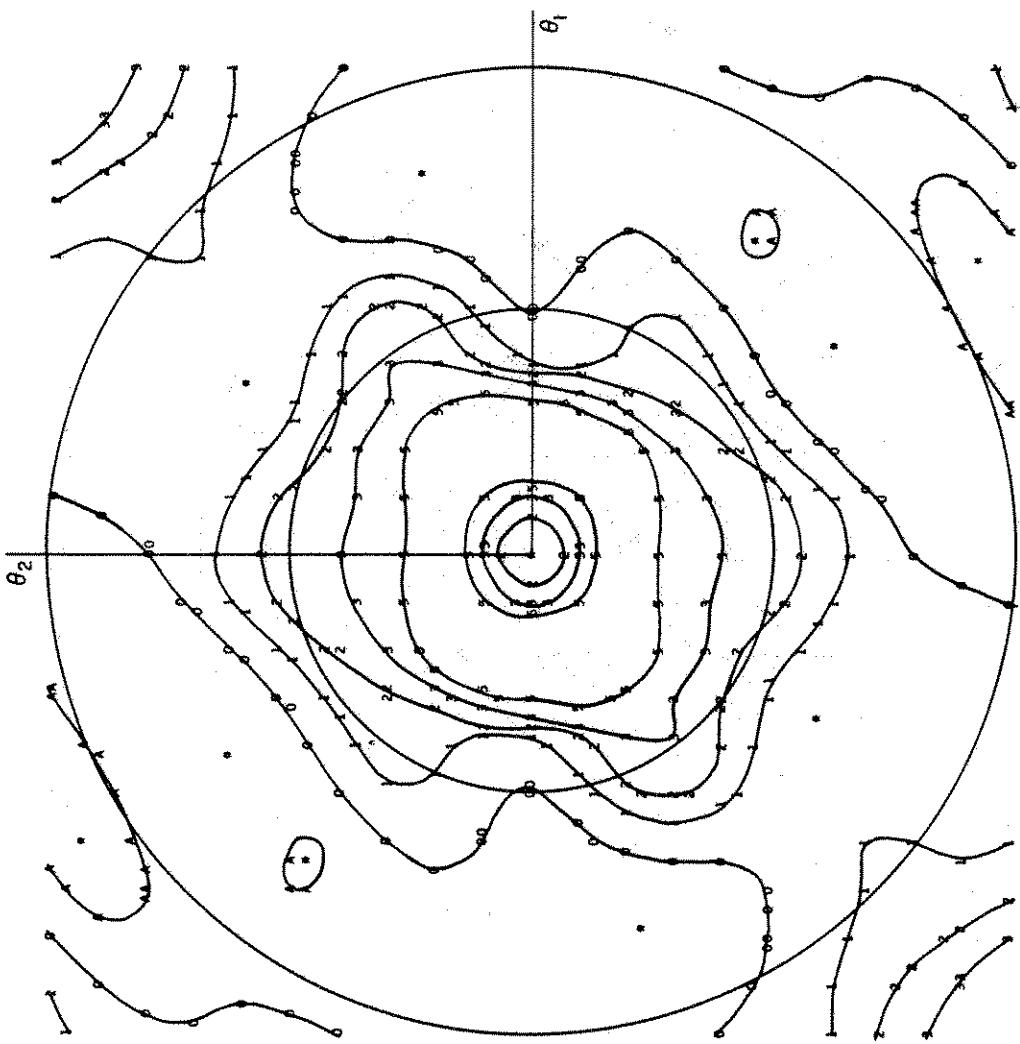


Figure 11b:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0$ ,  $\lambda = 5300 \text{ \AA}$ .

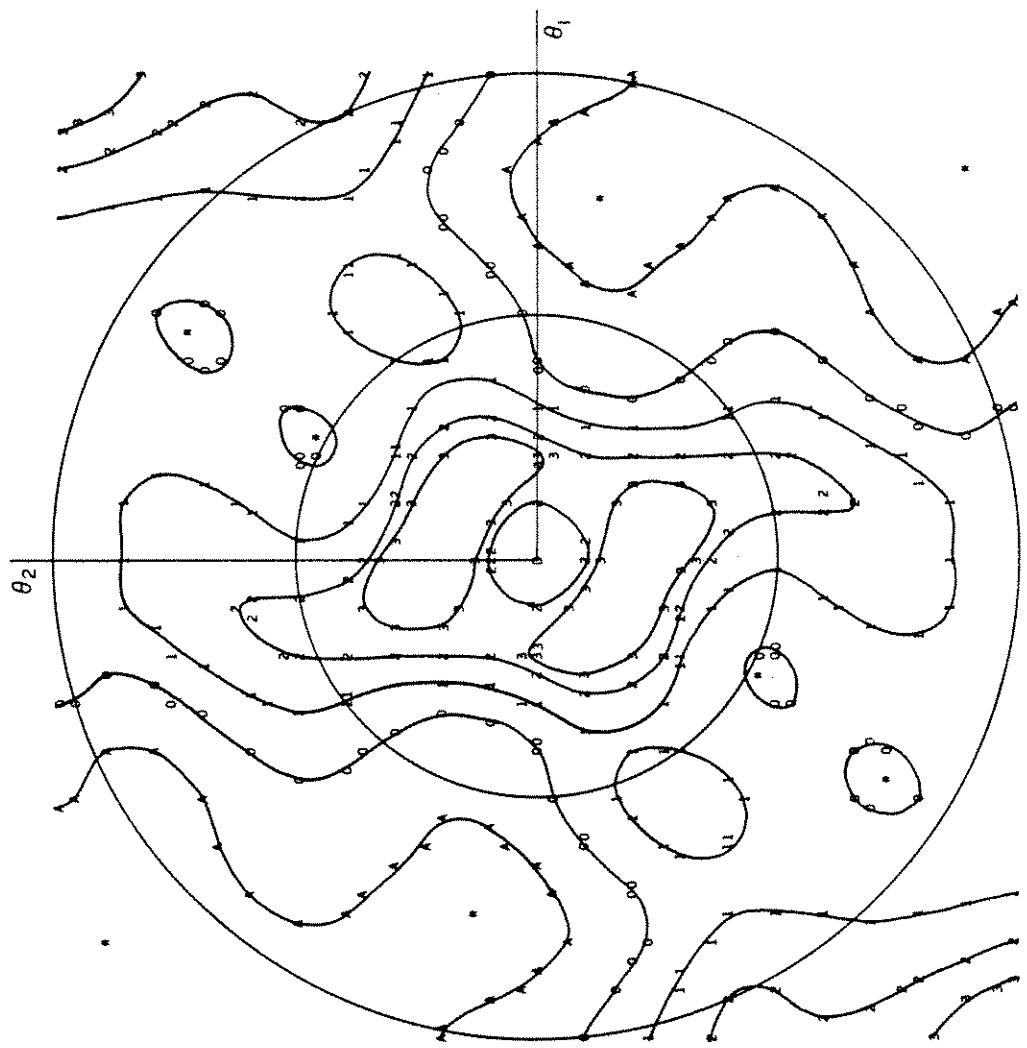


Figure 11c:  $\phi = 60^\circ$ ,  $\delta = 210^\circ$ ,  $\lambda = 5300 \text{ \AA}$ .

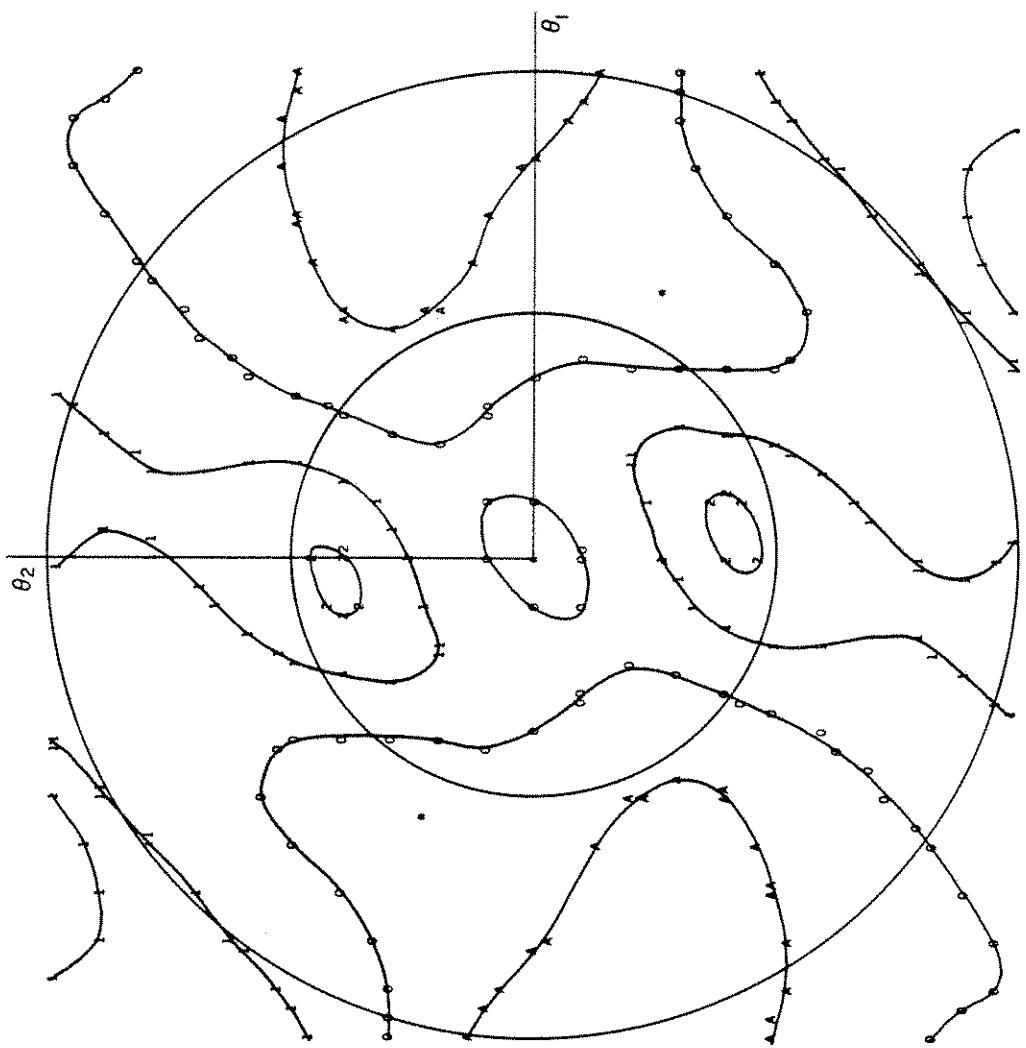
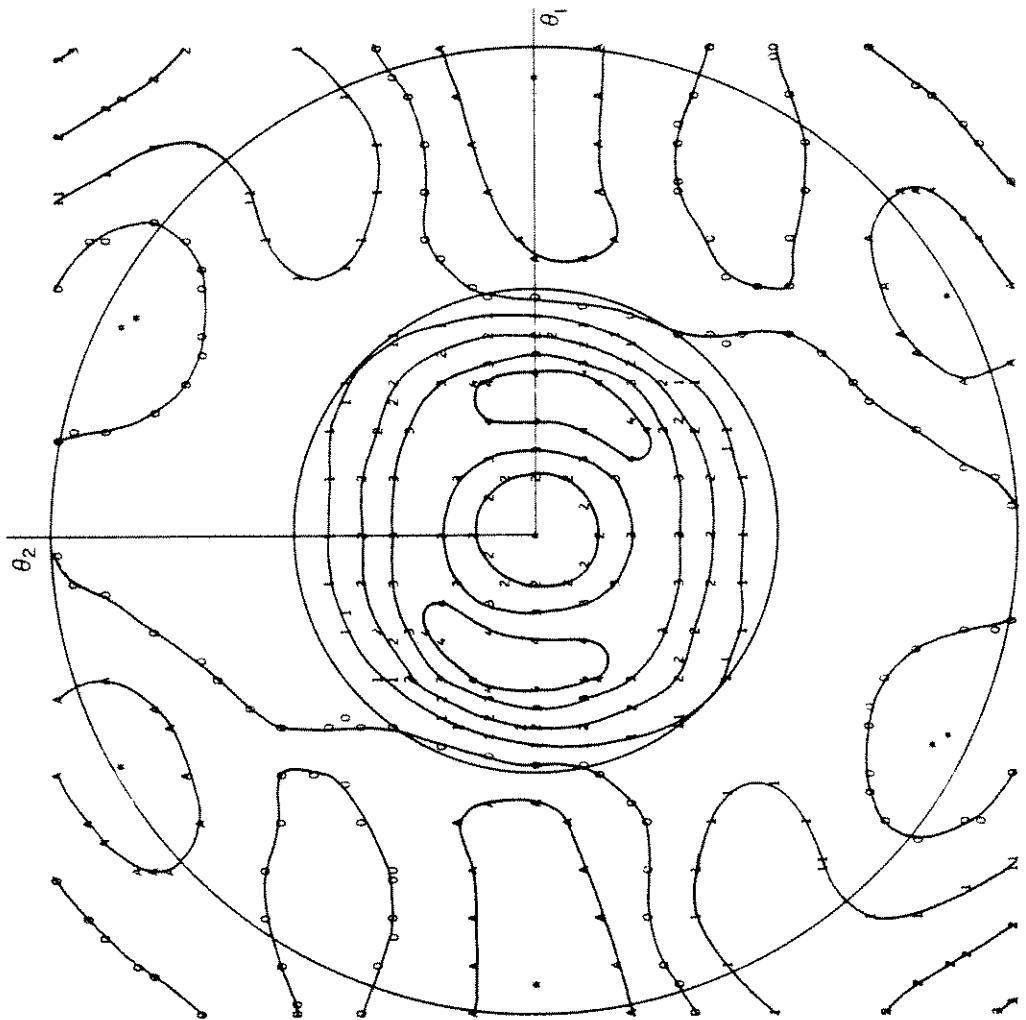


Figure 11d:  $\phi = 25^\circ$ ,  $\delta = 210$ ,  $\lambda = 6943 \text{ \AA}$ .

Figure 11e:  $\phi = 45^\circ$ ,  $\delta = 21^\circ 0$ ,  $\lambda = 6943 \text{ \AA}$ .



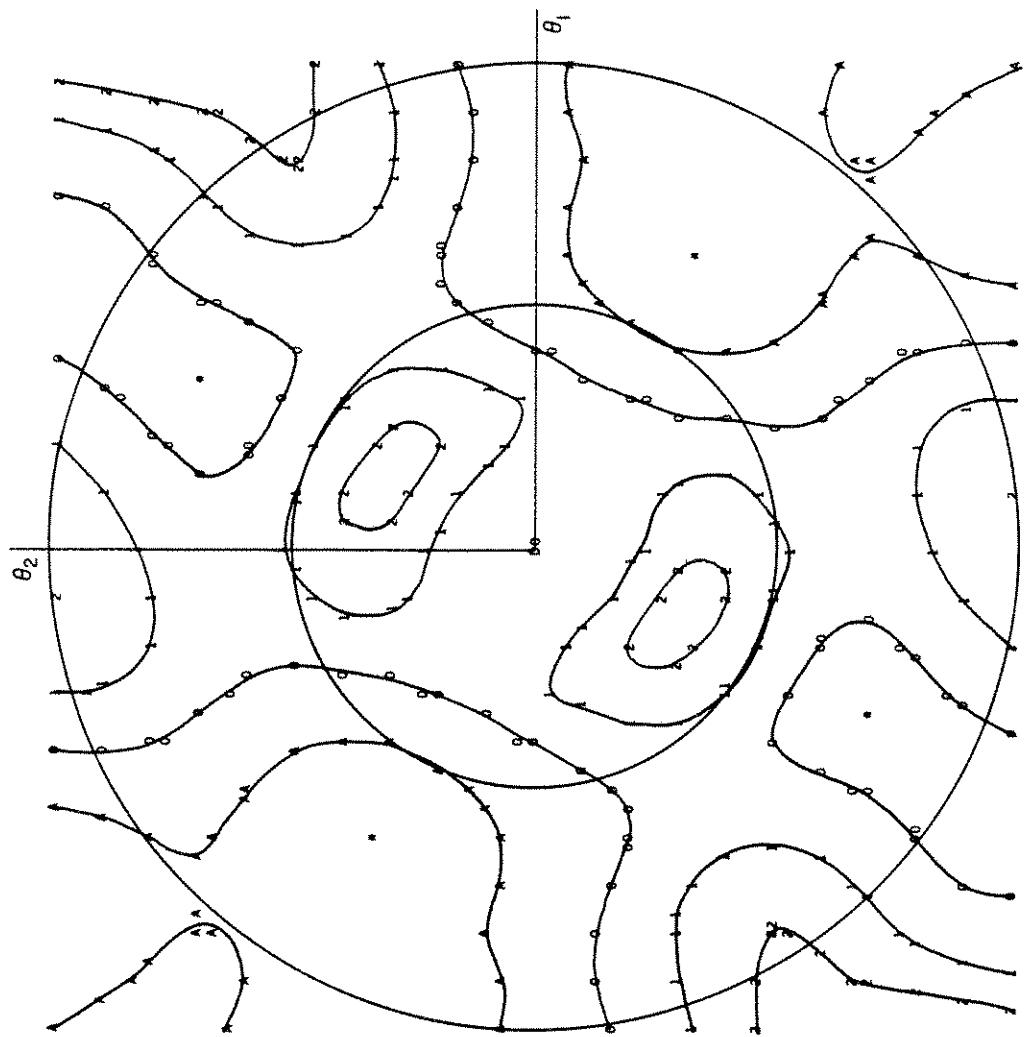


Figure 11f:  $\phi = 60^\circ$ ,  $\delta = 2^\circ 0$ ,  $\lambda = 6943 \text{ \AA}$ .

## 9. EFFECT OF OPTICAL COHERENCE

Because of coherent interference between the reflections from individual cube corners, the strength and shape of the laser echo from the Geos 3 array vary from pulse to pulse. This section contains data on the variations of the range correction due to coherent interference. A special set of calculations has been done to investigate the relationship between the incoherent range correction and the average of the coherent range corrections for different types of detection methods and different transmitted pulse lengths. Some sample pulse shapes are presented for both the coherent and the incoherent case.

Table 14 lists the coherent variation of the centroid range correction as a function of the incidence angle  $\phi$ . Each value is the rms variation of a set of 100 coherent returns. In Table 14a, each return has equal weight, while in Table 14b, each return is weighted by the ratio of the strength of the return to the strength of an incoherent return. This type of weighting reduces the rms deviation because of the fact that weaker pulses tend to have larger variations in centroid than do stronger pulses. In general, the fluctuation of the range correction decreases as the pulse length decreases. Since each rms deviation is computed from a limited number of coherent returns, the results should be considered as only an indication of the magnitude of the effect.

The range corrections given in Section 8 are all for the incoherent case. In the mathematical model used to calculate the transfer function, the incoherent centroid range correction is equal to the average of the coherent centroid range corrections when each pulse is weighted by its intensity. It is not obvious from the model what to expect for different weightings or for detection methods other than centroid detection. A series of computer runs has been done with a large number of coherent returns to see how big the differences are for Geos 3, and the results are presented in Table 15. The runs were made at an incidence angle of  $45^\circ$  with respect to the symmetry axis of the satellite. The table lists the coherent average minus the incoherent value ( $\Delta$ ), the standard deviation of an individual pulse ( $\sigma$ ), the number of coherent returns in the

Table 14. Root-mean-square deviation of centroid range correction due to coherent interference vs. incidence angle. a: All pulses have equal weight. b: Each pulse is weighted by the ratio of the strength of the pulse to the strength of an average (or incoherent) pulse.

a: Equal weighting

•2 NS. EQUAL WEIGHTING

PHI (DEG)	R.M.S. DEVIATION OF RANGE CORRECTION(METERS)	PHI (DEG)	R.M.S. DEVIATION OF RANGE CORRECTION(METERS)
0.0	.0094 *	0.0	.0086 *
10.0	.0202 *	10.0	.0187 *
20.0	.0190 *	20.0	.0181 *
30.0	.0189 *	30.0	.0166 *
40.0	.0198 *	40.0	.0181 *
50.0	.0189 *	50.0	.0159 *
60.0	.0192 *	60.0	.0169 *

b: Weighted by signal strength

•2 NS. WEIGHTED

5. NS. EQUAL WEIGHTING

PHI (DEG)	R.M.S. DEVIATION OF RANGE CORRECTION(METERS)	PHI (DEG)	R.M.S. DEVIATION OF RANGE CORRECTION(METERS)
0.0	.0259 *	0.0	.0104 *
10.0	.0636 *	10.0	.0364 *
20.0	.0666 *	20.0	.0354 *
30.0	.0718 *	30.0	.0434 *
40.0	.0588 *	40.0	.0294 *
50.0	.0719 *	50.0	.0414 *
60.0	.0479 *	60.0	.0365 *

20 NS. EQUAL WEIGHTING

20. NS. WEIGHTED

PHI (DEG)	R.M.S. DEVIATION OF RANGE CORRECTION(METERS)	PHI (DEG)	R.M.S. DEVIATION OF RANGE CORRECTION(METERS)
0.0	.0268 *	0.0	.0121 *
10.0	.0528 *	10.0	.0330 *
20.0	.0609 *	20.0	.0324 *
30.0	.0861 *	30.0	.0415 *
40.0	.0676 *	40.0	.0390 *
50.0	.0631 *	50.0	.0325 *
60.0	.0790 *	60.0	.0414 *

Table 15. Difference between the average range correction for a set of coherent returns and the range correction for the incoherent return. The pulse length is in nanoseconds;  $\Delta$ ,  $\sigma$ , and  $\sigma_m$  are in millimeters.

Pulse length	$\Delta$	$\sigma$	N	$\sigma_m$	$\Delta/\sigma_m$	Pulse length	$\Delta$	$\sigma$	N	$\sigma_m$	$\Delta/\sigma_m$
<u>a: Centroid, equal weighting</u>											
0.2	-8.15	20.95	1000	0.66	-12.3	0.2	-0.68	17.51	1000	0.55	-1.2
1.0	-9.56	35.89	1000	1.14	-8.4	1.0	-0.76	25.34	1000	0.80	-0.9
2.0	-7.64	47.57	1000	1.50	-5.1	2.0	-0.68	32.80	1000	1.04	-0.7
3.0	-4.67	58.46	1000	1.85	-2.5	3.0	+0.83	34.19	1000	1.08	+0.8
5.0	-2.34	70.06	1000	2.22	-1.1	5.0	+0.99	38.26	1000	1.21	+0.8
5.0	0.45	65.23	1000	2.06	+0.2	5.0	+0.80	36.59	1000	1.16	+0.7
<u>b: Centroid, weighted by signal strength</u>											
0.2	-5.94	13.53	300	0.78	-7.6	0.2	-4.25	10.39	300	0.60	-7.1
5.0	-4.20	67.75	1096	2.05	-2.1	5.0	-2.44	33.59	1096	1.01	-2.4
20.0	-2.97	94.43	1100	2.85	-1.0	20.0	-2.37	36.62	1100	1.10	-2.1
<u>c: Half-maximum, equal weighting</u>											
0.2	-10.32	22.80	300	1.32	-7.8	0.2	-3.99	18.59	300	1.07	-3.7
5.0	-2.87	68.32	1096	2.06	-1.4	5.0	+0.17	36.35	1096	1.10	0.2
20.0	-2.53	92.28	1100	2.78	-0.9	20.0	-1.76	37.46	1100	1.13	-1.6
<u>d: Half-maximum, weighted by signal strength</u>											
0.2	-10.32	22.80	300	1.32	-7.8	0.2	-3.99	18.59	300	1.07	-3.7
5.0	-2.87	68.32	1096	2.06	-1.4	5.0	+0.17	36.35	1096	1.10	0.2
20.0	-2.53	92.28	1100	2.78	-0.9	20.0	-1.76	37.46	1100	1.13	-1.6
<u>e: Half-area, equal weighting</u>											
0.2	-10.32	22.80	300	1.32	-7.8	0.2	-3.99	18.59	300	1.07	-3.7
5.0	-2.87	68.32	1096	2.06	-1.4	5.0	+0.17	36.35	1096	1.10	0.2
20.0	-2.53	92.28	1100	2.78	-0.9	20.0	-1.76	37.46	1100	1.13	-1.6
<u>f: Half-area, weighted by signal strength</u>											
0.2	-10.32	22.80	300	1.32	-7.8	0.2	-3.99	18.59	300	1.07	-3.7
5.0	-2.87	68.32	1096	2.06	-1.4	5.0	+0.17	36.35	1096	1.10	0.2
20.0	-2.53	92.28	1100	2.78	-0.9	20.0	-1.76	37.46	1100	1.13	-1.6

sample ( $N$ ), the standard deviation of the average ( $\sigma_m = \sigma/\sqrt{N}$ ), and the ratio of the difference  $\Delta$  to the standard deviation of the mean ( $\sigma_m$ ). The last column is a measure of the statistical significance of  $\Delta$ . In Table 15a, a statistically significant difference occurs between the coherent average and the incoherent value of the centroid range correction for short transmitted pulses; this difference decreases as the pulse length increases. The two runs for 5.0 nsec indicate no statistically significant difference. Table 15b shows the same set of coherent returns weighted by signal strength. For all pulse lengths, the bias in the coherent average is removed, in agreement with what should be expected from the model. In Table 15c, for half-maximum detection, the magnitude of the bias is smaller; this bias is not removed when the returns are weighted by signal strength (Table 15d). For half-area detection (Tables 15e and 15f), weighting seems to be somewhat more helpful but the bias still remains. The size of the bias in all cases is on the order of 1 cm or less. The data in Table 15 are probably typical of incidence angles from  $10^\circ$  to  $60^\circ$  or  $70^\circ$ . At  $\phi = 0^\circ$ , the distribution of reflectors along the line of sight is symmetrical, so there is no mechanism for producing a bias.

Sample pulse shapes for  $\phi = 0^\circ$  and  $45^\circ$  are shown in Figure 12. In each case, the incoherent return is given first, followed by one or more coherent returns. When the transmitted pulse is much longer than the array, as is the case for 20 and 5 nsec, the reflection has nearly the same gaussian shape as the incident pulse does. Only one coherent return is given in each case for these pulse lengths. The returns for 0.2 nsec tend to be irregularly shaped. Effects such as differences between the range correction for different types of detection systems and differences between the incoherent range correction and the average of the coherent range corrections seem to be associated with the pulse distortion that occurs when the pulse length is comparable to, or less than, the size of the array.

The position, in meters, listed in the first column of Figure 12 is measured with respect to the center of the pulse that would be received from a point reflector at the center of gravity of the satellite. The intensity in the second column is in normalized units such that the area under the curve is equal to the signal strength in equivalent number of cube corners at normal incidence.

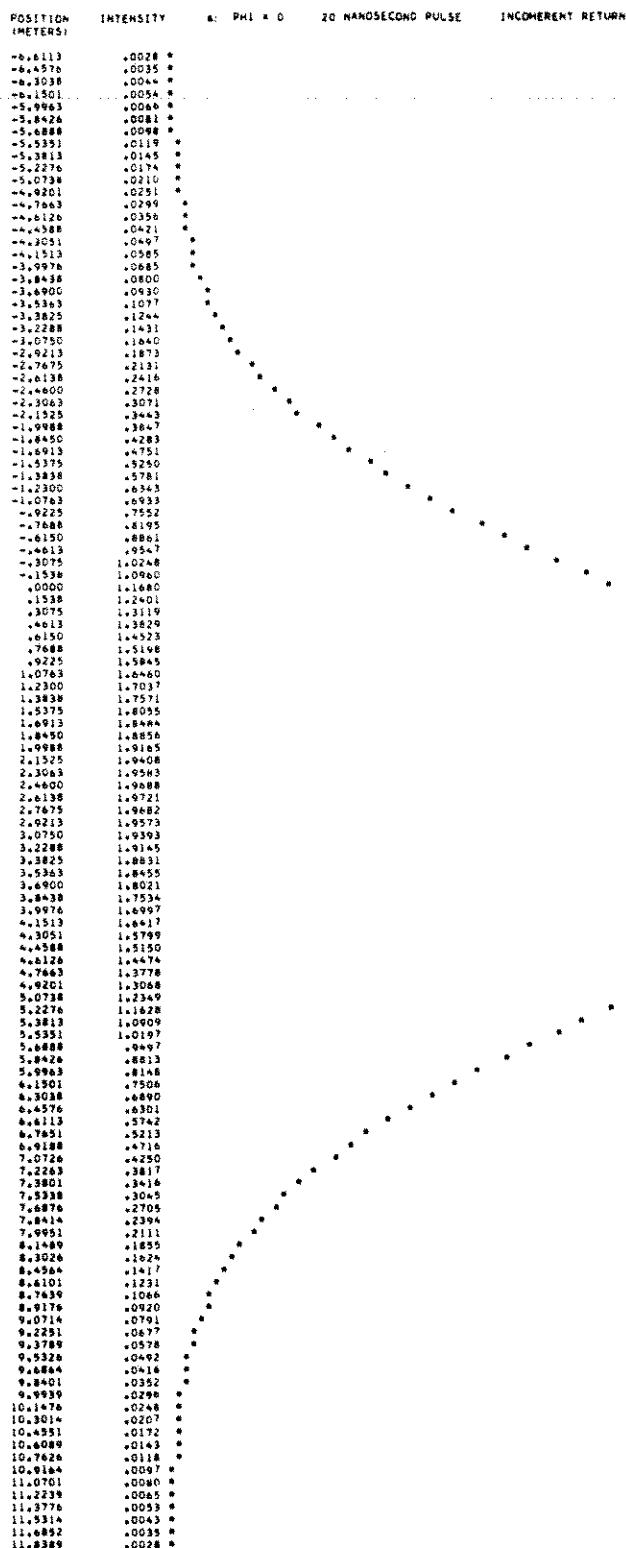


Figure 12. Sample incoherent and coherent reflected pulse shapes. The intensity is plotted vs. the distance along the line of sight.

POSITION (METERS)	INTENSITY	b: PHI = 0	20 NANOSECOND PULSE	COHERENT RETURN
-6.4113	.0052 *			
-6.4576	.0065 *			
-6.3038	.0080 *			
-6.1501	.0099 *			
-5.9963	.0121 *			
-5.8426	.0148 *			
-5.6888	.0181 *			
-5.5351	.0218 *			
-5.3813	.0246 *			
-5.2276	.0270 *			
-5.0738	.0295 *			
-4.9201	.0320 *			
-4.7663	.0349 *			
-4.6126	.0352 *			
-4.4588	.0372 *			
-4.3051	.0391 *			
-4.1513	.0471 *			
-3.9976	.1254 *			
-3.8438	.1443 *			
-3.6890	.1701 *			
-3.5353	.1970 *			
-3.3815	.2274 *			
-3.2288	.2515 *			
-3.0750	.2896 *			
-2.9213	.3420 *			
-2.7675	.3891 *			
-2.6138	.4409 *			
-2.4600	.4979 *			
-2.3063	.5602 *			
-2.1525	.6280 *			
-2.0088	.7014 *			
-1.8550	.7605 *			
-1.6913	.8455 *			
-1.5375	.9562 *			
-1.3838	1.0525 *			
-1.2300	1.1544 *			
-1.0763	1.2615 *			
-0.9225	1.3736 *			
-0.7686	1.4901 *			
-0.6150	1.6107 *			
-0.4613	1.7348 *			
-0.3075	1.8615 *			
-0.1535	1.9903 *			
.0000	2.1203 *			
.1535	2.2505 *			
.3075	2.3801 *			
.4613	2.5079 *			
.6150	2.6311 *			
.7688	2.7644 *			
.9225	2.8709 *			
1.0763	2.9814 *			
1.2300	3.0849 *			
1.3838	3.1804 *			
1.5375	3.2669 *			
1.6913	3.3438 *			
1.8550	3.4198 *			
2.0088	3.4444 *			
2.1525	3.5072 *			
2.3063	3.5376 *			
2.4600	3.5554 *			
2.6138	3.5602 *			
2.7675	3.5521 *			
2.9213	3.5311 *			
3.0750	3.4975 *			
3.2288	3.4317 *			
3.3815	3.3940 *			
3.5353	3.3252 *			
3.6890	3.2660 *			
3.8438	3.1571 *			
3.9976	3.0595 *			
4.1513	2.9541 *			
4.3051	2.8420 *			
4.4588	2.7742 *			
4.6138	2.6718 *			
4.7663	2.5759 *			
4.9201	2.4347 *			
5.0738	2.2177 *			
5.2288	2.0874 *			
5.3813	1.9577 *			
5.5351	1.8293 *			
5.6890	1.7032 *			
5.8438	1.5800 *			
6.0000	1.4506 *			
6.1513	1.3449 *			
6.3038	1.2340 *			
6.4588	1.1282 *			
6.6138	1.0277 *			
6.7663	.9328 *			
6.9201	.8435 *			
7.0738	.7600 *			
7.2288	.6813 *			
7.3813	.6103 *			
7.5351	.5440 *			
7.6890	.4830 *			
7.8438	.4276 *			
7.9976	.3768 *			
8.1513	.3309 *			
8.3038	.2898 *			
8.4588	.2525 *			
8.6138	.2194 *			
8.7663	.1919 *			
8.9201	.1638 *			
9.0738	.1408 *			
9.2288	.1205 *			
9.3813	.1028 *			
9.5351	.0874 *			
9.6890	.0740 *			
9.8438	.0625 *			
10.0000	.0524 *			
10.1513	.0430 *			
10.3038	.0367 *			
10.4588	.0308 *			
10.6089	.0253 *			
10.7626	.0209 *			
10.9164	.0172 *			
11.0701	.0141 *			
11.2239	.0115 *			
11.3776	.0096 *			
11.5314	.0076 *			
11.6852	.0061 *			
11.8389	.0049 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	at PHI = 0	5 NANOSECOND PULSE	INCOHERENT RETURN
.2734	.0097	*		
.3127	.0122	*		
.3518	.0151	*		
.3908	.0188	*		
.4300	.0222	*		
.4691	.0265	*		
.5082	.0305	*		
.5473	.0347	*		
.5864	.0359	*		
.6255	.0390	*		
.6646	.0426	*		
.7037	.0455	*		
.7428	.0486	*		
.7819	.0509	*		
.8209	.0557	*		
.8600	.0585	*		
.8991	.0598	*		
.9382	.0561	*		
.9773	.0501	*		
1.0164	.0454	*		
1.0555	.0405	*		
1.0946	.0371	*		
1.1337	.0350	*		
1.1728	.0327	*		
1.2119	.0300	*		
1.2510	.0285	*		
1.2901	.0275	*		
1.3291	.0267	*		
1.3682	.0261	*		
1.4073	.0259	*		
1.4464	.0256	*		
1.4855	.0250	*		
1.5246	.0247	*		
1.5637	.0240	*		
1.6028	.0235	*		
1.6419	.0233	*		
1.6810	.0236	*		
1.7201	.0240	*		
1.7592	.0249	*		
1.7983	.0254	*		
1.8374	.0259	*		
1.8764	.0260	*		
1.9155	.0269	*		
1.9546	.0276	*		
1.9937	.0283	*		
2.0328	.0294	*		
2.0719	.0302	*		
2.1110	.0313	*		
2.1501	.0326	*		
2.1892	.0344	*		
2.2283	.0366	*		
2.2674	.0391	*		
2.3065	.0411	*		
2.3456	.0436	*		
2.3846	.0467	*		
2.4237	.0502	*		
2.4628	.0542	*		
2.5019	.0582	*		
2.5410	.0622	*		
2.5801	.0662	*		
2.6192	.0702	*		
2.6583	.0742	*		
2.6974	.0782	*		
2.7365	.0812	*		
2.7756	.0842	*		
2.8147	.0871	*		
2.8538	.0900	*		
2.8929	.0930	*		
2.9319	.0954	*		
2.9710	.0988	*		
3.0101	.1022	*		
3.0492	.1050	*		
3.0883	.1084	*		
3.1274	.1116	*		
3.1665	.1147	*		
3.2056	.1181	*		
3.2447	.1211	*		
3.2838	.1241	*		
3.3229	.1263	*		
3.3620	.1288	*		
3.4011	.1303	*		
3.4402	.1302	*		
3.4792	.1308	*		
3.5183	.1347	*		
3.5574	.1364	*		
3.5965	.1380	*		
3.6356	.1390	*		
3.6747	.1398	*		
3.7138	.1399	*		
3.7529	.1373	*		
3.7920	.1408	*		
3.8311	.1254	*		
3.8702	.1139	*		
3.9093	.9848	*		
3.9484	.8775	*		
3.9874	.7613	*		
4.0265	.6656	*		
4.0656	.5767	*		
4.1047	.5031	*		
4.1438	.4349	*		
4.1829	.3746	*		
4.2220	.3214	*		
4.2611	.2747	*		
4.3002	.2340	*		
4.3393	.1985	*		
4.3784	.1678	*		
4.4175	.1413	*		
4.4566	.1185	*		
4.4956	.0991	*		
4.5347	.0825	*		
4.5738	.0684	*		
4.6129	.0565	*		
4.6520	.0466	*		
4.6911	.0382	*		
4.7302	.0312	*		
4.7693	.0254	*		
4.8084	.0206	*		
4.8475	.0166	*		
4.8866	.0134	*		
4.9257	.0107	*		
4.9648	.0086	*		

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	d: PHI = 0	S NANOSECOND PULSE	COHERENT RETURN
.2736	.0092 *			
.3127	.0115 *			
.3518	.0143 *			
.3909	.0177 *			
.4300	.0216 *			
.4691	.0268 *			
.5082	.0327 *			
.5473	.0399 *			
.5864	.0467 *			
.6255	.0537 *			
.6646	.0607 *			
.7037	.0684 *			
.7428	.0761 *			
.7819	.0841 *			
.8209	.0928 *			
.8600	.1011 *			
.8991	.1095 *			
.9382	.1174 *			
.9773	.1253 *			
1.0164	.1328 *			
1.0555	.1374 *			
1.0946	.1430 *			
1.1337	.1483 *			
1.1728	.1537 *			
1.2119	.1591 *			
1.2510	.1645 *			
1.2901	.1698 *			
1.3291	.1752 *			
1.3682	.1803 *			
1.4073	.1856 *			
1.4464	.1908 *			
1.4855	.1963 *			
1.5246	.2003 *			
1.5637	.2044 *			
1.6028	.2086 *			
1.6419	.2125 *			
1.6810	.2161 *			
1.7201	.2198 *			
1.7592	.2234 *			
1.7983	.2269 *			
1.8374	.2304 *			
1.8764	.2331 *			
1.9155	.2354 *			
1.9546	.2383 *			
1.9937	.2411 *			
2.0328	.2438 *			
2.0719	.2465 *			
2.1110	.2491 *			
2.1501	.2517 *			
2.1892	.2541 *			
2.2283	.2563 *			
2.2674	.2582 *			
2.3065	.2605 *			
2.3456	.2626 *			
2.3846	.2653 *			
2.4237	.2680 *			
2.4628	.2707 *			
2.5019	.2734 *			
2.5410	.2760 *			
2.5801	.2782 *			
2.6192	.2802 *			
2.6583	.2821 *			
2.6974	.2840 *			
2.7365	.2858 *			
2.7756	.2875 *			
2.8147	.2892 *			
2.8538	.2908 *			
2.8929	.2925 *			
2.9319	.2943 *			
2.9710	.2962 *			
3.0101	.2980 *			
3.0492	.2997 *			
3.0883	.3015 *			
3.1274	.3032 *			
3.1665	.3049 *			
3.2056	.3063 *			
3.2447	.3079 *			
3.2838	.3094 *			
3.3229	.3109 *			
3.3620	.3123 *			
3.4011	.3138 *			
3.4401	.3152 *			
3.4792	.3179 *			
3.5183	.3196 *			
3.5574	.3209 *			
3.5965	.3214 *			
3.6356	.3234 *			
3.6747	.3243 *			
3.7138	.3267 *			
3.7529	.3287 *			
3.7920	.3305 *			
3.8311	.3322 *			
3.8702	.3339 *			
3.9093	.3357 *			
3.9484	.3372 *			
3.9874	.3387 *			
4.0265	.3402 *			
4.0656	.3414 *			
4.1047	.3432 *			
4.1438	.3440 *			
4.1829	.3451 *			
4.2220	.3469 *			
4.2611	.3474 *			
4.3002	.3489 *			
4.3393	.3504 *			
4.3784	.3529 *			
4.4175	.3542 *			
4.4566	.3554 *			
4.4956	.3562 *			
4.5347	.3571 *			
4.5738	.3574 *			
4.6129	.3582 *			
4.6520	.3585 *			
4.6911	.3591 *			
4.7302	.3607 *			
4.7693	.3613 *			
4.8084	.3616 *			
4.8475	.3616 *			
4.8866	.3610 *			
4.9257	.3601 *			
4.9648	.3604 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	e: PHI = 0	+2 NANUSECOND PULSE	INCOHERENT RETURN
2.4460	.0273 *			
2.4464	.0344 *			
2.4488	.0566 *			
2.4712	.0800 *			
2.4736	.1125 *			
2.4760	.1568 *			
2.4784	.2168 *			
2.4808	.2424 *			
2.4832	.3028 *			
2.4856	.4416 *			
2.4880	.7222 *			
2.4905	.9566 *			
2.4929	1.2506 *			
2.4953	1.6240 *			
2.4977	2.0933 *			
2.5001	2.6770 *			
2.5025	3.3729 *			
2.5049	4.2283 *			
2.5073	5.2543 *			
2.5097	6.4724 *			
2.5121	7.9035 *			
2.5145	9.5674 *			
2.5169	11.4815 *			
2.5193	13.599 *			
2.5217	16.1123 *			
2.5241	18.8433 *			
2.5265	21.8505 *			
2.5289	25.1250 *			
2.5313	28.6497 *			
2.5337	32.3998 *			
2.5361	36.3347 *			
2.5385	40.368 *			
2.5409	44.4615 *			
2.5433	48.9005 *			
2.5457	53.1814 *			
2.5481	57.3660 *			
2.5505	61.4690 *			
2.5529	65.4103 *			
2.5553	69.1471 *			
2.5577	72.4647 *			
2.5601	75.111 *			
2.5625	78.7877 *			
2.5649	81.103 *			
2.5673	83.7283 *			
2.5697	85.7503 *			
2.5721	87.4938 *			
2.5745	88.9807 *			
2.5769	90.2392 *			
2.5793	91.4644 *			
2.5817	92.1890 *			
2.5841	92.9384 *			
2.5865	93.5722 *			
2.5889	94.1110 *			
2.5913	94.5711 *			
2.5937	94.9836 *			
2.5961	95.2953 *			
2.5985	95.514 *			
2.6009	95.7855 *			
2.6033	95.9629 *			
2.6057	96.0395 *			
2.6081	96.0738 *			
2.6105	96.0451 *			
2.6129	95.9540 *			
2.6153	95.8019 *			
2.6177	95.5907 *			
2.6201	95.3119 *			
2.6225	94.0944 *			
2.6249	94.6085 *			
2.6273	94.1548 *			
2.6297	93.6235 *			
2.6321	92.9990 *			
2.6345	92.2608 *			
2.6369	91.3840 *			
2.6393	90.3348 *			
2.6418	89.1012 *			
2.6442	87.6355 *			
2.6466	85.9163 *			
2.6490	83.9194 *			
2.6514	81.6281 *			
2.6538	79.0327 *			
2.6562	76.1328 *			
2.6586	72.9378 *			
2.6610	69.413 *			
2.6634	65.7906 *			
2.6658	61.8257 *			
2.6682	57.7378 *			
2.6706	53.5375 *			
2.6730	49.2791 *			
2.6754	45.0178 *			
2.6778	40.8078 *			
2.6802	36.944 *			
2.6826	32.7422 *			
2.6850	28.9736 *			
2.6874	25.6278 *			
2.6898	22.1304 *			
2.6922	19.0989 *			
2.6946	16.3433 *			
2.6970	13.8662 *			
2.7014	11.6338 *			
2.7038	9.7746 *			
2.7062	8.0414 *			
2.7064	8.5904 *			
2.7090	5.3543 *			
2.7114	4.3121 *			
2.7138	3.4424 *			
2.7162	2.7241 *			
2.7186	2.1367 *			
2.7210	1.6613 *			
2.7234	1.4453 *			
2.7258	1.0781 *			
2.7282	.7406 *			
2.7306	.5558 *			
2.7330	.4134 *			
2.7354	.3048 *			
2.7378	.2228 *			
2.7402	.1614 *			
2.7426	.104 *			
2.7450	.0825 *			
2.7474	.0582 *			
2.7498	.0407 *			
2.7522	.0262 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	E - PHI X 0	+Z NANOSECOND PULSE	COHERENT RETURN
2.4660	.0436 *			
2.4664	.0632 *			
2.4668	.0909 *			
2.4712	.1296 *			
2.4736	.1831 *			
2.4760	.2056 *			
2.4764	.2367 *			
2.4808	.4410 *			
2.4832	.4678 *			
2.4856	.9105 *			
2.4880	1.2238 *			
2.4905	1.6316 *			
2.4929	2.1576 *			
2.4953	2.8295 *			
2.4977	3.0114 *			
2.5001	4.7516 *			
2.5025	6.0443 *			
2.5049	7.7297 *			
2.5073	9.7438 *			
2.5097	12.1883 *			
2.5121	15.1301 *			
2.5145	18.6406 *			
2.5169	22.7700 *			
2.5193	27.7075 *			
2.5217	33.3357 *			
2.5241	26.8878 *			
2.5265	47.4014 *			
2.5289	55.9223 *			
2.5313	65.5345 *			
2.5337	76.2788 *			
2.5361	88.4499 *			
2.5385	101.3245 *			
2.5409	115.6628 *			
2.5433	131.2071 *			
2.5457	147.9299 *			
2.5481	165.7829 *			
2.5505	184.6957 *			
2.5529	204.5755 *			
2.5553	225.4508 *			
2.5577	246.7516 *			
2.5601	268.7503 *			
2.5625	291.1223 *			
2.5649	313.6678 *			
2.5673	336.1696 *			
2.5697	358.3954 *			
2.5721	380.1007 *			
2.5745	401.3221 *			
2.5769	422.9116 *			
2.5793	449.5306 *			
2.5817	456.6011 *			
2.5841	471.8701 *			
2.5865	485.1153 *			
2.5889	496.1256 *			
2.5913	504.7157 *			
2.5937	510.7316 *			
2.5961	514.0535 *			
2.5985	519.1011 *			
2.6009	512.3622 *			
2.6033	507.3248 *			
2.6057	499.5583 *			
2.6081	489.1997 *			
2.6105	476.3114 *			
2.6129	461.1770 *			
2.6153	443.9872 *			
2.6177	425.0313 *			
2.6201	400.7055 *			
2.6225	382.9103 *			
2.6249	360.3419 *			
2.6273	337.2368 *			
2.6297	313.8304 *			
2.6321	290.4353 *			
2.6345	267.3147 *			
2.6369	244.7077 *			
2.6393	222.6211 *			
2.6418	201.3570 *			
2.6442	181.8915 *			
2.6466	163.0952 *			
2.6490	145.5239 *			
2.6514	129.2277 *			
2.6538	114.2093 *			
2.6562	100.4769 *			
2.6586	87.9983 *			
2.6610	74.7547 *			
2.6634	64.4178 *			
2.6658	57.5818 *			
2.6682	49.5630 *			
2.6706	42.4795 *			
2.6730	36.2532 *			
2.6754	30.8065 *			
2.6778	26.0641 *			
2.6802	21.3539 *			
2.6826	18.4080 *			
2.6850	15.3829 *			
2.6874	12.7599 *			
2.6898	10.5456 *			
2.6922	8.6709 *			
2.6946	7.0918 *			
2.6970	5.7485 *			
2.7014	4.9485 *			
2.7018	3.7514 *			
2.7042	2.6984 *			
2.7066	2.3818 *			
2.7090	1.9797 *			
2.7114	1.4738 *			
2.7138	1.1478 *			
2.7162	.8876 *			
2.7186	.6818 *			
2.7210	.5207 *			
2.7234	.3936 *			
2.7258	.2957 *			
2.7282	.2206 *			
2.7306	.1632 *			
2.7330	.1199 *			
2.7354	.0873 *			
2.7378	.0631 *			
2.7402	.0453 *			
2.7426	.0315 *			
2.7450	.0227 *			
2.7474	.0159 *			
2.7498	.0110 *			
2.7522	.0076 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\phi$ : PHI = 0	+2 NANOSECOND PULSE	COHERENT RETURN
2.4640	.0073	*		
2.4644	.0104	*		
2.4658	.0154	*		
2.4712	.0220	*		
2.4736	.0312	*		
2.4760	.0439	*		
2.4784	.0613	*		
2.4808	.0850	*		
2.4832	.1188	*		
2.4856	.1592	*		
2.4880	.1944	*		
2.4885	.2891	*		
2.4929	.3851	*		
2.4953	.5091	*		
2.4977	.6680	*		
2.5001	.8699	*		
2.5025	1.1245	*		
2.5049	1.4453	*		
2.5073	1.8049	*		
2.5097	2.1265	*		
2.5121	2.4930	*		
2.5145	3.8472	*		
2.5169	4.5201	*		
2.5193	5.5646	*		
2.5217	6.8055	*		
2.5241	8.2693	*		
2.5255	9.4141	*		
2.5289	11.9790	*		
2.5313	14.2838	*		
2.5337	16.9284	*		
2.5361	19.9424	*		
2.5385	23.3538	*		
2.5409	27.1888	*		
2.5433	31.4705	*		
2.5457	34.8748	*		
2.5481	41.4444	*		
2.5505	47.1573	*		
2.5529	53.3569	*		
2.5553	60.0333	*		
2.5577	67.1675	*		
2.5601	74.7253	*		
2.5625	82.7765	*		
2.5649	90.9943	*		
2.5673	98.4950	*		
2.5697	108.2179	*		
2.5721	117.0298	*		
2.5745	125.8258	*		
2.5769	134.4911	*		
2.5793	142.9625	*		
2.5817	150.9315	*		
2.5841	158.4468	*		
2.5865	166.3181	*		
2.5889	171.4199	*		
2.5913	176.6352	*		
2.5937	180.8598	*		
2.5961	184.0059	*		
2.5985	186.0056	*		
2.6009	186.8135	*		
2.6033	186.8066	*		
2.6057	186.7955	*		
2.6081	182.0157	*		
2.6105	178.1159	*		
2.6129	173.1820	*		
2.6153	167.3168	*		
2.6177	160.6403	*		
2.6201	153.2881	*		
2.6225	145.3959	*		
2.6249	137.1512	*		
2.6273	126.5588	*		
2.6297	119.4521	*		
2.6321	111.3263	*		
2.6345	102.8553	*		
2.6369	94.6085	*		
2.6393	86.6779	*		
2.6418	79.1273	*		
2.6442	72.0130	*		
2.6466	55.1261	*		
2.6490	53.1347	*		
2.6514	53.4054	*		
2.6538	48.1360	*		
2.6562	43.3079	*		
2.6586	38.8966	*		
2.6610	34.8736	*		
2.6634	31.2090	*		
2.6658	27.4777	*		
2.6682	24.8359	*		
2.6706	22.0718	*		
2.6730	19.5562	*		
2.6754	17.2879	*		
2.6778	15.1883	*		
2.6802	13.3015	*		
2.6826	11.5935	*		
2.6850	10.0525	*		
2.6874	8.4675	*		
2.6898	7.4287	*		
2.6922	6.3267	*		
2.6946	5.3524	*		
2.6970	4.4968	*		
2.6994	3.7509	*		
2.7018	3.1055	*		
2.7042	2.5516	*		
2.7066	2.0208	*		
2.7090	1.4825	*		
2.7114	1.3498	*		
2.7138	1.0741	*		
2.7162	.8476	*		
2.7186	.6633	*		
2.7210	.4517	*		
2.7234	.3960	*		
2.7258	.3021	*		
2.7282	.2244	*		
2.7306	.1713	*		
2.7330	.1273	*		
2.7354	.0938	*		
2.7378	.0685	*		
2.7402	.0496	*		
2.7426	.0256	*		
2.7450	.0253	*		
2.7474	.0179	*		
2.7498	.0125	*		
2.7522	.0086	*		

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\theta$ : PHASE = 0	+2 NANOSECOND PULSE	COHERENT RETURN
2.4640	.0032	*		
2.4664	.0047	*		
2.4688	.0057	*		
2.4712	.0066	*		
2.4736	.0137	*		
2.4760	.0192	*		
2.4784	.0267	*		
2.4808	.0370	*		
2.4832	.0507	*		
2.4856	.0889	*		
2.4880	.0930	*		
2.4905	.0954	*		
2.4929	.1655	*		
2.4953	.2182	*		
2.4977	.2853	*		
2.5001	.3708	*		
2.5025	.4780	*		
2.5049	.6116	*		
2.5073	.7771	*		
2.5097	.8865	*		
2.5121	.1238	*		
2.5145	.1587	*		
2.5169	.1489	*		
2.5193	.2320	*		
2.5217	.2831	*		
2.5241	.3433	*		
2.5265	.4138	*		
2.5289	.4477	*		
2.5313	.5029	*		
2.5337	.6483	*		
2.5361	.8225	*		
2.5385	.9674	*		
2.5409	11.2046	*		
2.5433	12.9671	*		
2.5457	14.9231	*		
2.5481	17.0278	*		
2.5505	19.4330	*		
2.5529	21.9861	*		
2.5553	24.7298	*		
2.5577	27.6494	*		
2.5601	30.7246	*		
2.5625	33.9761	*		
2.5649	37.2166	*		
2.5673	40.4544	*		
2.5697	44.8703	*		
2.5721	47.1144	*		
2.5745	50.2167	*		
2.5769	53.0815	*		
2.5793	55.6453	*		
2.5817	57.8189	*		
2.5841	59.5209	*		
2.5865	60.6753	*		
2.5889	63.0758	*		
2.5913	61.0842	*		
2.5937	60.2520	*		
2.5961	58.6959	*		
2.5985	56.4243	*		
2.6009	53.4886	*		
2.6033	49.8859	*		
2.6057	45.7581	*		
2.6081	41.4104	*		
2.6105	34.3074	*		
2.6129	31.2498	*		
2.6153	26.1664	*		
2.6177	21.2101	*		
2.6201	16.5297	*		
2.6225	12.2632	*		
2.6249	8.5316	*		
2.6273	5.4327	*		
2.6297	3.21	*		
2.6321	1.3849	*		
2.6345	.4843	*		
2.6369	.3118	*		
2.6393	.8146	*		
2.6418	1.9140	*		
2.6442	3.5102	*		
2.6466	5.4683	*		
2.6490	7.44	*		
2.6514	10.0924	*		
2.6538	12.4703	*		
2.6562	14.7452	*		
2.6586	16.8189	*		
2.6610	18.6107	*		
2.6634	20.0599	*		
2.6658	21.1268	*		
2.6682	21.7624	*		
2.6706	21.4778	*		
2.6730	21.6399	*		
2.6754	21.4709	*		
2.6778	20.9336	*		
2.6802	19.6584	*		
2.6826	18.4197	*		
2.6850	17.0331	*		
2.6874	15.5523	*		
2.6898	13.72	*		
2.6922	12.5020	*		
2.6946	11.0144	*		
2.6970	9.5947	*		
2.6994	8.2862	*		
2.7018	7.0448	*		
2.7042	5.9403	*		
2.7066	4.9567	*		
2.7090	4.0344	*		
2.7114	3.3442	*		
2.7138	2.7080	*		
2.7162	2.1898	*		
2.7186	1.7214	*		
2.7210	1.3524	*		
2.7234	1.0522	*		
2.7258	.8108	*		
2.7282	.6197	*		
2.7306	.4670	*		
2.7330	.3504	*		
2.7354	.2400	*		
2.7378	.1911	*		
2.7402	.1391	*		
2.7426	.1004	*		
2.7450	.0717	*		
2.7474	.0508	*		
2.7498	.0356	*		
2.7522	.0248	*		

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\phi = \text{PHI} = 0$	+2 NANOSECOND PULSE	COHERENT RETURN
2.4640	.0170 *			
2.4666	.0245 *			
2.4688	.0350 *			
2.4712	.0495 *			
2.4736	.0694 *			
2.4760	.0984 *			
2.4784	.1327 *			
2.4808	.1810 *			
2.4832	.24 *			
2.4856	.3275 *			
2.4880	.4345 *			
2.4905	.5711 *			
2.4929	.7438 *			
2.4953	.9596 *			
2.4977	1.2265 *			
2.5001	1.5530 *			
2.5025	1.9 *			
2.5049	2.4202 *			
2.5073	2.9785 *			
2.5097	3.6308 *			
2.5121	4.3836 *			
2.5145	5.2117 *			
2.5169	6.2077 *			
2.5193	7.2868 *			
2.5217	8.4569 *			
2.5241	9.7151 *			
2.5265	11.0824 *			
2.5289	12.5037 *			
2.5313	13.9725 *			
2.5337	15.4663 *			
2.5361	16.9666 *			
2.5385	18.4307 *			
2.5409	19.9000 *			
2.5433	21.2074 *			
2.5457	22.4762 *			
2.5481	23.6616 *			
2.5505	24.7574 *			
2.5529	25.7813 *			
2.5553	26.7612 *			
2.5577	27.7388 *			
2.5601	28.7046 *			
2.5625	29.9226 *			
2.5649	31.2761 *			
2.5673	32.9250 *			
2.5697	34.9578 *			
2.5721	37.4721 *			
2.5745	40.5601 *			
2.5769	44.3053 *			
2.5793	48.1161 *			
2.5817	51.0363 *			
2.5841	60.0921 *			
2.5865	66.9676 *			
2.5889	74.0334 *			
2.5913	83.0372 *			
2.5937	92.0963 *			
2.5961	101.7066 *			
2.5985	111.7358 *			
2.6009	122.0266 *			
2.6033	132.1229 *			
2.6057	142.7146 *			
2.6081	152.7473 *			
2.6105	162.3273 *			
2.6129	171.2774 *			
2.6153	179.4318 *			
2.6177	186.6411 *			
2.6201	192.7556 *			
2.6225	198.7936 *			
2.6249	201.4260 *			
2.6273	203.7936 *			
2.6297	204.8219 *			
2.6321	204.5928 *			
2.6345	202.8997 *			
2.6369	199.9396 *			
2.6393	195.8105 *			
2.6418	190.5952 *			
2.6442	186.2244 *			
2.6466	177.1135 *			
2.6490	169.1998 *			
2.6514	160.5591 *			
2.6538	151.4470 *			
2.6562	141.9596 *			
2.6586	132.2308 *			
2.6610	122.3899 *			
2.6634	112.5594 *			
2.6658	103.0725 *			
2.6682	93.3718 *			
2.6706	84.2081 *			
2.6730	75.4368 *			
2.6754	67.1280 *			
2.6778	59.3260 *			
2.6802	52.0691 *			
2.6826	45.4666 *			
2.6850	38.2170 *			
2.6874	33.7423 *			
2.6898	28.7813 *			
2.6922	24.3698 *			
2.6946	20.4816 *			
2.6970	17.0849 *			
2.6994	14.1436 *			
2.7018	11.1924 *			
2.7042	9.4711 *			
2.7066	7.6610 *			
2.7090	6.1478 *			
2.7114	4.8945 *			
2.7138	3.8655 *			
2.7162	3.0284 *			
2.7186	2.3534 *			
2.7210	1.8139 *			
2.7234	1.3837 *			
2.7258	1.0514 *			
2.7282	.7905 *			
2.7306	.5894 *			
2.7330	.3359 *			
2.7354	.3196 *			
2.7378	.2323 *			
2.7402	.1675 *			
2.7426	.14 *			
2.7450	.0949 *			
2.7474	.0596 *			
2.7498	.0415 *			
2.7522	.0287 *			

Figure 12. (Cont.).

POSITION (METERS)	INTENSITY	$\phi = 0$	+2 NANOSECOND PULSE	COHERENT RETURN
2.4460	.0006	*		
2.4464	.0012	*		
2.4468	.0017	*		
2.4472	.0024	*		
2.4476	.0036	*		
2.4480	.0049	*		
2.4484	.0069	*		
2.4488	.0099	*		
2.4492	.0131	*		
2.4496	.0183	*		
2.4498	.0251	*		
2.4503	.0330	*		
2.4509	.0459	*		
2.4513	.0614	*		
2.4517	.0816	*		
2.4521	.1076	*		
2.4525	.1344	*		
2.4529	.1643	*		
2.4533	.2027	*		
2.4537	.3072	*		
2.4541	.3929	*		
2.4545	.4995	*		
2.4549	.6312	*		
2.4553	.7929	*		
2.4557	.9444	*		
2.4561	1.2208	*		
2.4565	1.5186	*		
2.4569	1.8645	*		
2.4573	2.2766	*		
2.4577	2.7642	*		
2.4581	3.3377	*		
2.4585	4.0081	*		
2.4589	4.8455	*		
2.4593	5.6946	*		
2.4597	6.7138	*		
2.4601	7.8854	*		
2.4605	9.2095	*		
2.4609	10.6955	*		
2.4613	12.3508	*		
2.4617	14.1808	*		
2.4621	16.1882	*		
2.4625	18.3726	*		
2.4629	20.7300	*		
2.4633	23.2525	*		
2.4637	25.9283	*		
2.4641	28.7413	*		
2.4645	31.6717	*		
2.4649	34.6960	*		
2.4653	37.7877	*		
2.4657	41.0184	*		
2.4661	44.0582	*		
2.4665	47.1776	*		
2.4669	50.2482	*		
2.4673	53.2443	*		
2.4677	56.1439	*		
2.4681	58.4298	*		
2.4685	61.5905	*		
2.4689	64.1217	*		
2.4693	66.1110	*		
2.4697	68.7977	*		
2.4701	70.9618	*		
2.4705	73.0280	*		
2.4709	75.0123	*		
2.4713	76.4307	*		
2.4717	78.7965	*		
2.4721	80.6185	*		
2.4725	82.4000	*		
2.4729	84.1322	*		
2.4733	85.8032	*		
2.4737	87.3872	*		
2.4741	88.6504	*		
2.4745	90.1504	*		
2.4749	91.2382	*		
2.4753	92.0807	*		
2.4757	92.3313	*		
2.4761	92.4920	*		
2.4765	92.3982	*		
2.4769	91.6641	*		
2.4773	90.3987	*		
2.4776	88.6399	*		
2.4780	86.3709	*		
2.4784	83.6020	*		
2.4788	80.3605	*		
2.4792	76.5979	*		
2.4796	72.6363	*		
2.4800	68.2759	*		
2.4804	63.6730	*		
2.4808	58.9060	*		
2.4812	54.0535	*		
2.4816	49.1923	*		
2.4820	44.3953	*		
2.4824	39.7291	*		
2.4828	35.1618	*		
2.4832	31.0118	*		
2.4836	27.0670	*		
2.4840	23.5856	*		
2.4844	20.0445	*		
2.4848	17.0313	*		
2.4852	14.3647	*		
2.4856	11.9762	*		
2.4860	9.6111	*		
2.4864	8.1351	*		
2.4868	6.4105	*		
2.4872	5.3276	*		
2.4876	4.2558	*		
2.4880	3.3687	*		
2.4884	2.6445	*		
2.4888	2.0371	*		
2.4892	1.5860	*		
2.4896	1.2140	*		
2.4900	.9540	*		
2.4904	.6891	*		
2.4908	.5128	*		
2.4912	.3782	*		
2.4916	.2766	*		
2.4920	.2003	*		
2.4924	.1438	*		
2.4928	.1026	*		
2.4932	.0722	*		
2.4936	.0505	*		
2.4940	.0350	*		

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\lambda$ : PHI = 0	.2 NANOSECOND PULSE	COHERENT RETURN
2.4460	.0226 *			
2.4464	.0327 *			
2.4488	.0469 *			
2.4712	.0687 *			
2.4736	.0960 *			
2.4740	.1313 *			
2.4784	.1820 *			
2.4818	.2404 *			
2.4832	.3400 *			
2.4856	.4596 *			
2.4880	.6152 *			
2.4905	.8166 *			
2.4929	1.0747 *			
2.4953	1.4024 *			
2.4977	1.8141 *			
2.5001	2.3285 *			
2.5025	2.9429 *			
2.5049	3.7388 *			
2.5073	4.6791 *			
2.5097	5.8079 *			
2.5121	7.1503 *			
2.5145	8.7320 *			
2.5169	10.4900 *			
2.5193	12.3124 *			
2.5217	15.1578 *			
2.5241	17.9328 *			
2.5265	21.0520 *			
2.5289	24.5264 *			
2.5313	28.3599 *			
2.5337	32.5505 *			
2.5361	37.9889 *			
2.5385	43.9586 *			
2.5409	47.1357 *			
2.5433	52.5840 *			
2.5457	58.2811 *			
2.5481	64.1684 *			
2.5505	70.2030 *			
2.5529	76.3337 *			
2.5553	82.1713 *			
2.5577	88.4703 *			
2.5601	94.7708 *			
2.5625	100.7592 *			
2.5649	106.5903 *			
2.5673	112.2239 *			
2.5697	117.6263 *			
2.5721	122.7700 *			
2.5745	127.7440 *			
2.5769	132.2074 *			
2.5793	136.4408 *			
2.5817	140.4442 *			
2.5841	144.1318 *			
2.5865	147.5219 *			
2.5889	150.6356 *			
2.5913	153.4867 *			
2.5937	156.0879 *			
2.5961	159.4528 *			
2.5985	162.1111 *			
2.6009	162.5148 *			
2.6033	164.2259 *			
2.6057	165.7264 *			
2.6081	167.0124 *			
2.6105	168.0754 *			
2.6129	168.9018 *			
2.6153	169.4733 *			
2.6177	170.9472 *			
2.6201	176.7569 *			
2.6225	188.4132 *			
2.6249	188.7049 *			
2.6273	197.4602 *			
2.6297	198.0681 *			
2.6321	194.0799 *			
2.6345	191.6108 *			
2.6369	195.912 *			
2.6393	197.1396 *			
2.6418	191.1980 *			
2.6442	146.6461 *			
2.6466	141.0359 *			
2.6490	136.1538 *			
2.6514	130.2348 *			
2.6538	123.9258 *			
2.6562	117.2817 *			
2.6586	110.3659 *			
2.6610	103.0030 *			
2.6634	94.0024 *			
2.6658	88.7058 *			
2.6682	81.4352 *			
2.6706	74.2455 *			
2.6730	67.2678 *			
2.6754	50.5071 *			
2.6778	54.0407 *			
2.6802	47.4542 *			
2.6826	42.1778 *			
2.6850	36.8489 *			
2.6874	31.9504 *			
2.6898	27.4914 *			
2.6922	23.4714 *			
2.6946	19.8830 *			
2.6970	16.7100 *			
2.7014	11.9314 *			
2.7018	11.0115 *			
2.7042	9.4513 *			
2.7066	7.6899 *			
2.7090	6.2053 *			
2.7114	4.9660 *			
2.7138	3.9413 *			
2.7162	3.0101 *			
2.7186	2.4205 *			
2.7210	1.8505 *			
2.7234	1.4374 *			
2.7258	1.0930 *			
2.7282	.8249 *			
2.7306	.6165 *			
2.7330	.4574 *			
2.7354	.3383 *			
2.7378	.2451 *			
2.7402	.1771 *			
2.7426	.1204 *			
2.7450	.0901 *			
2.7474	.0834 *			
2.7498	.0442 *			
2.7522	.0309 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\phi$	PHI + D	$\omega_2$ NANOSECOND PULSE	COHERENT RETURN
2.4460	.0387	*			
2.4464	.0557	*			
2.4468	.0705	*			
2.46712	.1123	*			
2.4736	.1573	*			
2.4760	.2182	*			
2.4784	.3000	*			
2.4808	.4687	*			
2.4832	.5515	*			
2.4856	.6343	*			
2.4880	.7763	*			
2.4905	1.2858	■■			
2.4929	1.6642	*			
2.4953	2.1417	*			
2.4977	2.7297	*			
2.5001	3.4455	*			
2.5025	4.3065	*			
2.5049	5.2676	*			
2.5073	6.5370	*			
2.5097	7.9223	*			
2.5121	9.5655	*			
2.5145	11.2973	*			
2.5169	13.2618	*			
2.5193	15.4483	*			
2.5217	17.7719	*			
2.5241	20.2205	*			
2.5265	22.7442	*			
2.5289	25.2846	*			
2.5313	27.7772	*			
2.5337	30.1270	*			
2.5361	32.2613	*			
2.5385	34.0875	*			
2.5409	35.5123	*			
2.5433	36.4457	*			
2.5457	38.5114	*			
2.5481	39.5933	*			
2.5505	35.7177	*			
2.5529	34.1436	*			
2.5553	31.9421	*			
2.5577	29.1447	*			
2.5601	25.8533	*			
2.5625	22.1731	*			
2.5649	18.4291	*			
2.5673	14.4444	*			
2.5697	10.4481	*			
2.5721	6.9471	*			
2.5745	3.9863	*			
2.5769	1.7585	*			
2.5793	*4362	*			
2.5817	*1619	*			
2.5841	*1.04	*			
2.5865	*1.1709	*			
2.5889	*6.4450	*			
2.5913	10.9432	*			
2.5937	16.5365	*			
2.5961	23.0901	*			
2.5985	30.4795	*			
2.6009	36.3461	*			
2.6033	40.4771	*			
2.6057	39.9956	*			
2.6081	63.7414	*			
2.6105	71.1211	*			
2.6129	78.4199	*			
2.6153	64.9466	*			
2.6177	50.5520	*			
2.6201	95.1049	*			
2.6225	98.5427	*			
2.6249	100.4065	*			
2.6273	101.9077	*			
2.6297	101.8694	*			
2.6321	100.7574	*			
2.6345	98.1597	*			
2.6369	95.6641	*			
2.6393	91.9521	*			
2.6418	87.5930	*			
2.6442	82.7410	*			
2.6466	77.1500	*			
2.6490	72.2706	*			
2.6514	68.4930	*			
2.6538	60.8971	*			
2.6562	55.3741	*			
2.6586	50.0015	*			
2.6610	44.8431	*			
2.6634	39.9487	*			
2.6658	35.3553	*			
2.6682	31.4141	*			
2.6706	27.1610	*			
2.6730	23.4812	*			
2.6754	20.3643	*			
2.6778	17.4422	*			
2.6802	14.8609	*			
2.6826	12.5828	*			
2.6850	10.5873	*			
2.6874	8.5525	*			
2.6898	7.1522	*			
2.6922	6.6724	*			
2.6946	4.9812	*			
2.6970	4.0599	*			
2.6994	3.2859	*			
2.7018	2.6437	*			
2.7042	2.1121	*			
2.7066	1.7760	*			
2.7090	1.3749	*			
2.7114	1.0337	*			
2.7138	.6033	*			
2.7162	.6198	*			
2.7186	.4748	*			
2.7210	.3611	*			
2.7234	.2726	*			
2.7258	.2042	*			
2.7282	.1518	*			
2.7306	.1121	*			
2.7330	.0821	*			
2.7354	.0596	*			
2.7378	.0330	*			
2.7402	.0107	*			
2.7426	.0218	*			
2.7450	.0154	*			
2.7474	.0107	*			
2.7498	.0074	*			
2.7522	.0051	*			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	m: PHI = 0	.2 NANOSECOND PULSE	COHERENT RETURN
2.4640	.0520	*		
2.4664	.0750	*		
2.4688	.1074	*		
2.4712	.1524	*		
2.4736	.2144	*		
2.4760	.2988	*		
2.4784	.4128	*		
2.4808	.5828	*		
2.4832	.7676	*		
2.4856	1.0323	*		
2.4880	1.3764	*		
2.4905	1.4193	*		
2.4929	2.3832	*		
2.4953	3.0944	*		
2.4977	3.9822	*		
2.5000	5.0000	*		
2.5023	4.3119	*		
2.5049	6.0473	*		
2.5073	9.9949	*		
2.5097	12.3041	*		
2.5121	15.0129	*		
2.5145	18.1559	*		
2.5169	21.7625	*		
2.5193	25.4545	*		
2.5217	30.4437	*		
2.5241	35.5283	*		
2.5265	41.0963	*		
2.5289	47.1127	*		
2.5313	53.5288	*		
2.5337	60.2759	*		
2.5361	67.2662	*		
2.5385	74.3437	*		
2.5409	81.5358	*		
2.5433	88.5558	*		
2.5457	95.3068	*		
2.5481	101.3351	*		
2.5505	107.3869	*		
2.5529	112.4119	*		
2.5553	116.3704	*		
2.5577	119.7337	*		
2.5601	122.1003	*		
2.5625	122.7100	*		
2.5649	122.3875	*		
2.5673	120.4254	*		
2.5697	118.0392	*		
2.5721	114.6776	*		
2.5745	109.0210	*		
2.5769	102.9331	*		
2.5793	96.5840	*		
2.5817	88.5040	*		
2.5841	80.4002	*		
2.5865	71.9599	*		
2.5889	63.3727	*		
2.5913	56.8195	*		
2.5937	46.4660	*		
2.5961	38.5368	*		
2.5985	31.1949	*		
2.6009	26.3908	*		
2.6033	18.4328	*		
2.6057	11.3408	*		
2.6081	9.1742	*		
2.6105	5.9664	*		
2.6129	3.7250	*		
2.6153	2.6325	*		
2.6177	2.5480	*		
2.6201	2.4640	*		
2.6225	2.3768	*		
2.6249	5.6325	*		
2.6273	8.0884	*		
2.6297	10.9862	*		
2.6321	14.2024	*		
2.6345	17.6110	*		
2.6369	21.0904	*		
2.6393	24.5203	*		
2.6418	27.1515	*		
2.6442	30.4054	*		
2.6466	33.7774	*		
2.6490	35.7381	*		
2.6514	37.5355	*		
2.6538	38.8350	*		
2.6562	39.6198	*		
2.6586	39.8800	*		
2.6610	39.9617	*		
2.6634	38.4431	*		
2.6658	37.8421	*		
2.6682	36.3445	*		
2.6706	34.5307	*		
2.6730	32.4633	*		
2.6754	30.2085	*		
2.6778	27.4237	*		
2.6802	25.1757	*		
2.6826	22.0156	*		
2.6850	20.4947	*		
2.6874	18.1548	*		
2.6898	15.9299	*		
2.6922	13.8465	*		
2.6946	11.9234	*		
2.6970	10.1723	*		
2.6994	8.5945	*		
2.7018	7.1215	*		
2.7042	5.0744	*		
2.7066	4.9145	*		
2.7090	4.0047	*		
2.7114	3.2338	*		
2.7138	2.5877	*		
2.7162	2.0520	*		
2.7186	1.6126	*		
2.7210	1.2300	*		
2.7234	.9404	*		
2.7258	.74615	*		
2.7282	.5921	*		
2.7306	.4223	*		
2.7330	.31145	*		
2.7354	.2321	*		
2.7378	.1697	*		
2.7402	.1230	*		
2.7426	.1044	*		
2.7450	.0629	*		
2.7474	.0444	*		
2.7498	.0311	*		
2.7522	.0215	*		

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	R: PHI = 0	+2 NANOSECOND PULSE	COHERENT RETURN
2.4840	.017*			
2.4884	.0255*			
2.4888	.0345*			
2.4712	.0518*			
2.4736	.0728*			
2.4760	.1014*			
2.4784	.1140*			
2.4818	.1184*			
2.4832	.1249*			
2.4856	.1344*			
2.4880	.1484*			
2.4905	.1616*			
2.4929	.1803*			
2.4953	1.0432*			
2.4977	1.3412*			
2.5001	1.7084*			
2.5025	2.0423*			
2.5049	2.1215*			
2.5073	3.3517*			
2.5097	4.1218*			
2.5121	5.0242*			
2.5145	6.0764*			
2.5169	7.2704*			
2.5193	8.6318*			
2.5217	10.2494*			
2.5241	11.8544*			
2.5265	13.7140*			
2.5289	15.7310*			
2.5313	17.8933*			
2.5337	20.1845*			
2.5361	22.5834*			
2.5385	25.0635*			
2.5409	28.6113*			
2.5433	30.1916*			
2.5457	32.7143*			
2.5481	35.2278*			
2.5505	37.6721*			
2.5529	40.0194*			
2.5553	42.2457*			
2.5577	44.3311*			
2.5601	46.5064*			
2.5625	48.0231*			
2.5649	49.6129*			
2.5673	51.0270*			
2.5697	52.2651*			
2.5721	53.3277*			
2.5745	54.2150*			
2.5769	54.9252*			
2.5793	55.5338*			
2.5817	56.7721*			
2.5841	58.9271*			
2.5865	59.8420*			
2.5889	59.5165*			
2.5913	59.9283*			
2.5937	54.0551*			
2.5961	52.8789*			
2.5985	51.3778*			
2.6009	49.4467*			
2.6033	47.3930*			
2.6057	44.9193*			
2.6081	42.1524*			
2.6105	39.1284*			
2.6129	35.8954*			
2.6153	32.5117*			
2.6177	29.0443*			
2.6201	25.5656*			
2.6225	22.4500*			
2.6249	19.7056*			
2.6273	15.7556*			
2.6297	12.9846*			
2.6321	10.4864*			
2.6345	8.3365*			
2.6369	6.5554*			
2.6393	5.1490*			
2.6418	4.1031*			
2.6442	3.1019*			
2.6466	2.0231*			
2.6490	2.9020*			
2.6514	2.9889*			
2.6538	3.2615*			
2.6562	3.6372*			
2.6586	4.0760*			
2.6610	4.5319*			
2.6634	4.9455*			
2.6658	5.3447*			
2.6682	5.6654*			
2.6706	5.8517*			
2.6730	5.9552*			
2.6754	5.9548*			
2.6778	5.8552*			
2.6802	5.6657*			
2.6826	5.3940*			
2.6850	5.0702*			
2.6874	4.6950*			
2.6898	4.2863*			
2.6922	3.8678*			
2.6946	3.4441*			
2.6970	3.0295*			
2.6994	2.6332*			
2.7018	2.2624*			
2.7042	1.9441*			
2.7066	1.6445*			
2.7090	1.3316*			
2.7114	1.1029*			
2.7138	.8971*			
2.7162	.7222*			
2.7186	.5755*			
2.7210	.4539*			
2.7234	.3445*			
2.7258	.2748*			
2.7282	.2098*			
2.7306	.1591*			
2.7330	.1194*			
2.7354	.0888*			
2.7378	.0655*			
2.7402	.0477*			
2.7426	.0345*			
2.7450	.0217*			
2.7474	.0175*			
2.7498	.0123*			
2.7522	.0086*			

Figure 12. (Cont.)

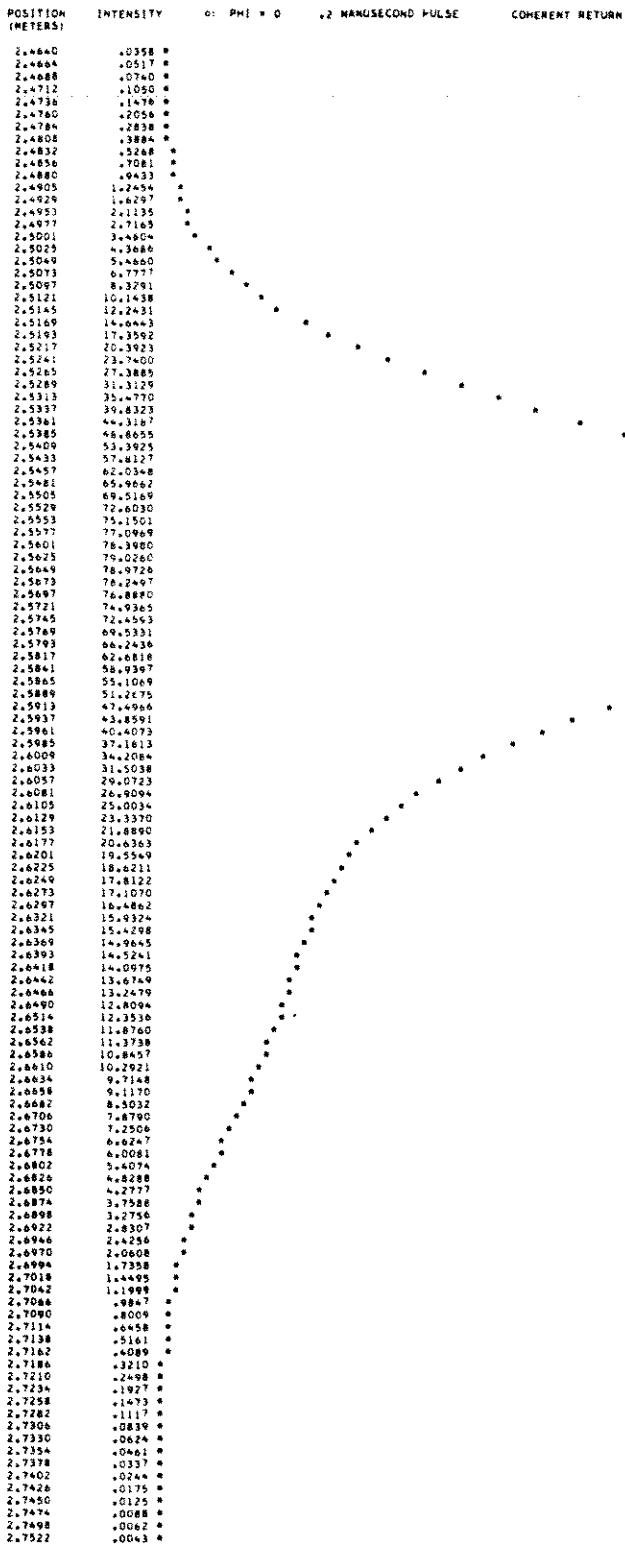


Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	P: PHI = 45	20 NANOSECOND PULSE	INCOHERENT RETURN
-7.5980	.0025	*		
-7.4363	.0034	*		
-7.1177	.0051	*		
-7.1130	.0053	*		
-6.9513	.0067	*		
-6.7897	.0084	*		
-6.6280	.0106	*		
-6.4664	.0133	*		
-6.3047	.0164	*		
-6.1431	.0206	*		
-5.9814	.025	*		
-5.8197	.0315	*		
-5.6581	.0386	*		
-5.5964	.0473	*		
-5.3348	.0576	*		
-5.1731	.0699	*		
-5.0114	.0845	*		
-4.8498	.1011	*		
-4.6881	.119	*		
-4.5265	.1398	*		
-4.3648	.1592	*		
-4.2031	.1792	*		
-4.0415	.2051	*		
-3.8798	.2420	*		
-3.7182	.2844	*		
-3.5565	.3379	*		
-3.4948	.3990	*		
-3.3332	.4610	*		
-3.1715	.5201	*		
-2.9099	.5884	*		
-2.7482	.6565	*		
-2.5865	.7241	*		
-2.4249	.7915	*		
-2.2632	.8582	*		
-2.1016	.9246	*		
-1.9399	.9910	*		
-1.7783	1.0583	*		
-1.6166	1.1263	*		
-1.4549	1.1941	*		
-1.3016	1.2613	*		
-1.2393	1.3284	*		
-1.1316	1.3954	*		
-0.9700	1.4613	*		
-0.8083	1.5285	*		
-0.6466	1.5956	*		
-0.4850	1.6627	*		
-0.3233	1.7297	*		
-0.1617	1.7967	*		
0.0000	1.8637	*		
0.1617	1.9308	*		
0.3233	1.9978	*		
0.4850	2.0647	*		
0.6466	2.1317	*		
0.8083	2.1986	*		
0.9700	2.2656	*		
1.1316	2.3326	*		
1.2393	2.3996	*		
1.4549	2.4666	*		
1.6166	2.5336	*		
1.7783	2.6006	*		
1.9399	2.6676	*		
2.1016	2.7346	*		
2.2632	2.8016	*		
2.4249	2.8686	*		
2.5865	2.9356	*		
2.7482	3.0026	*		
2.9099	3.0696	*		
3.0715	3.1366	*		
3.2332	3.2036	*		
3.3950	3.2706	*		
3.5565	3.3376	*		
3.7182	3.4046	*		
3.8798	3.4716	*		
4.0415	3.5386	*		
4.2031	3.6056	*		
4.3648	3.6726	*		
4.5265	3.7396	*		
4.6881	3.8066	*		
4.8500	3.8736	*		
5.0114	3.9406	*		
5.1731	3.9701	*		
5.3348	4.0371	*		
5.4964	4.1041	*		
5.6581	4.1711	*		
5.8197	4.2381	*		
5.9814	4.3051	*		
6.1431	4.3721	*		
6.3047	4.4391	*		
6.4666	4.5061	*		
6.6280	4.5731	*		
6.7897	4.6401	*		
6.9513	4.7071	*		
7.1130	4.7741	*		
7.2747	4.8411	*		
7.4363	4.9081	*		
7.5980	4.9751	*		
7.7596	5.0421	*		
7.9213	5.1091	*		
8.0830	5.1761	*		
8.2446	5.2431	*		
8.4063	5.3101	*		
8.5679	5.3771	*		
8.7296	5.4441	*		
8.8913	5.5111	*		
9.0529	5.5781	*		
9.2146	5.6451	*		
9.3762	5.7121	*		
9.5379	5.7791	*		
9.6996	5.8461	*		
9.8612	5.9131	*		
10.0229	5.9801	*		
10.1845	6.0471	*		
10.3462	6.1141	*		
10.5079	6.1811	*		
10.6695	6.2481	*		
10.8312	6.3151	*		
10.9928	6.3721	*		
11.1545	6.4291	*		
11.3161	6.4861	*		
11.4778	6.5431	*		
11.6395	6.6101	*		
11.8011	6.6691	*		

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	q: PHI = 45	20 NANOSECOND PULSE	COHERENT RETURN
-7.5980	.0002 *			
-7.4363	.0003 *			
-7.3570	.0004 *			
-7.1130	.0005 *			
-6.9513	.0006 *			
-6.7897	.0008 *			
-6.6280	.0010 *			
-6.4664	.0013 *			
-6.3047	.0017 *			
-6.1431	.0022 *			
-5.9814	.0027 *			
-5.8197	.0035 *			
-5.6581	.0044 *			
-5.4964	.0054 *			
-5.3348	.0068 *			
-5.1731	.0084 *			
-5.0114	.0104 *			
-4.8498	.0128 *			
-4.6881	.0158 *			
-4.5265	.0190 *			
-4.3648	.0231 *			
-4.2031	.0279 *			
-4.0415	.0338 *			
-3.8798	.0402 *			
-3.7182	.0480 *			
-3.5565	.0571 *			
-3.3948	.0675 *			
-3.2332	.0795 *			
-3.0715	.0933 *			
-2.9099	.1090 *			
-2.7482	.1268 *			
-2.5865	.1469 *			
-2.4249	.1694 *			
-2.2632	.1946 *			
-2.1016	.2226 *			
-1.9399	.2535 *			
-1.7783	.2870 *			
-1.6166	.3248 *			
-1.4549	.3655 *			
-1.2933	.4092 *			
-1.1316	.4565 *			
-0.9700	.5070 *			
-0.8083	.5608 *			
-0.6466	.6177 *			
-0.4850	.6776 *			
-0.3233	.7401 *			
-0.1617	.8051 *			
.0000	.8721 *			
.1617	.9407 *			
.3233	1.0106 *			
.4850	1.0811 *			
.6466	1.1511 *			
.8083	1.2219 *			
.9700	1.2906 *			
1.1316	1.3582 *			
1.2933	1.4231 *			
1.4549	1.4849 *			
1.6166	1.5430 *			
1.7783	1.5967 *			
1.9399	1.6454 *			
2.1016	1.6866 *			
2.2632	1.7284 *			
2.4249	1.7565 *			
2.5865	1.7804 *			
2.7482	1.7972 *			
2.9099	1.8066 *			
3.0715	1.8086 *			
3.2332	1.8031 *			
3.4049	1.7902 *			
3.5656	1.7771 *			
3.7182	1.7540 *			
3.8798	1.7092 *			
4.0415	1.6693 *			
4.2031	1.6235 *			
4.3648	1.5725 *			
4.5265	1.5168 *			
4.6881	1.4571 *			
4.8498	1.3940 *			
5.0114	1.3262 *			
5.1731	1.2602 *			
5.3348	1.1909 *			
5.4964	1.1207 *			
5.6581	1.0503 *			
5.8197	.9803 *			
5.9814	.9113 *			
6.1431	.8436 *			
6.3047	.7777 *			
6.4664	.7141 *			
6.6280	.6530 *			
6.7897	.5946 *			
6.9513	.5393 *			
7.1130	.4871 *			
7.2747	.4381 *			
7.4363	.3925 *			
7.5980	.3532 *			
7.7598	.3111 *			
7.9213	.2753 *			
8.0830	.2420 *			
8.2446	.2130 *			
8.4063	.1861 *			
8.5679	.1620 *			
8.7296	.1405 *			
8.8813	.1193 *			
9.0529	.1043 *			
9.2146	.0893 *			
9.3762	.0762 *			
9.5379	.0647 *			
9.6996	.0547 *			
9.8612	.0461 *			
10.0229	.0387 *			
10.1845	.0323 *			
10.3462	.0269 *			
10.5079	.0223 *			
10.6695	.0184 *			
10.8312	.0151 *			
10.9928	.0124 *			
11.1545	.0101 *			
11.3161	.0082 *			
11.4778	.0066 *			
11.6395	.0053 *			
11.8011	.0043 *			

Figure 12. (Cont.)

POSITION (NETLAS)	INTENSITY	E: PHZ + 45	S: NANUSECOND PULSE	INCOHERENT RETURN
-0.5580	.0002 *			
-0.6110	.0002 *			
-0.5840	.0003 *			
-0.5170	.0005 *			
-0.4700	.0007 *			
-0.4230	.0009 *			
-0.3760	.0013 *			
-0.3290	.0015 *			
-0.2820	.0016 *			
-0.2350	.0032 *			
-0.1880	.0043 *			
-0.1410	.0058 *			
-0.0940	.0078 *			
-0.0470	.0103 *			
.0000	.0137 *			
.0470	.0180 *			
.0940	.0215 *			
.1410	.0267 *			
.1880	.0397 *			
.2350	.0513 *			
.2820	.0658 *			
.3290	.0841 *			
.3760	.1068 *			
.4230	.1354 *			
.4700	.1700 *			
.5170	.2129 *			
.5640	.2652 *			
.6110	.3288 *			
.6580	.4056 *			
.7050	.4997 *			
.7520	.6078 *			
.7990	.7384 *			
.8460	.8770 *			
.8930	1.0736 *			
.9400	1.2847 *			
.9870	1.5295 *			
1.0340	1.8117 *			
1.0810	2.1350 *			
1.1280	2.5033 *			
1.1750	2.9200 *			
1.2220	3.3777 *			
1.2690	3.9125 *			
1.3160	4.4941 *			
1.3630	5.1352 *			
1.4100	5.8304 *			
1.4570	6.6032 *			
1.5040	7.4296 *			
1.5510	8.3113 *			
1.5980	9.2445 *			
1.6450	10.2556 *			
1.6920	11.352 *			
1.7390	12.3939 *			
1.7860	13.5168 *			
1.8330	14.6646 *			
1.8800	15.8289 *			
1.9270	16.9922 *			
1.9740	18.1559 *			
2.0210	19.1809 *			
2.0680	20.3773 *			
2.1150	21.6732 *			
2.1620	22.4047 *			
2.2090	23.3080 *			
2.2560	24.1704 *			
2.3030	24.4297 *			
2.3500	25.4254 *			
2.3970	26.111 *			
2.4440	26.3408 *			
2.4910	26.4473 *			
2.5380	26.5149 *			
2.5850	26.6421 *			
2.6320	26.7301 *			
2.6790	25.8821 *			
2.7260	25.4035 *			
2.7730	24.8016 *			
2.8200	24.466 *			
2.8670	23.7462 *			
2.9140	22.3553 *			
2.9610	21.1661 *			
3.0080	20.3121 *			
3.0550	19.2074 *			
3.1020	18.0662 *			
3.1490	16.9024 *			
3.1960	15.7413 *			
3.2430	14.5507 *			
3.2890	13.4052 *			
3.3370	12.2765 *			
3.3840	11.1828 *			
3.4310	10.1322 *			
3.4780	9.1313 *			
3.5250	8.1653 *			
3.5720	7.2811 *			
3.6190	6.4724 *			
3.6660	5.7083 *			
3.7130	5.0093 *			
3.7600	4.3716 *			
3.8070	3.7947 *			
3.8540	3.2762 *			
3.9010	2.8135 *			
3.9480	2.4403 *			
3.9950	2.1177 *			
4.0420	1.7753 *			
4.0890	1.4501 *			
4.1360	1.2123 *			
4.1830	1.0080 *			
4.2300	.8337 *			
4.2770	.6858 *			
4.3240	.5611 *			
4.3710	.4588 *			
4.4180	.3660 *			
4.4650	.2970 *			
4.5120	.23x3 *			
4.5590	.1898 *			
4.6060	.1503 *			
4.6530	.1184 *			
4.7000	.0928 *			
4.7470	.0724 *			
4.7940	.0536 *			
4.8410	.0433 *			
4.8880	.0332 *			
4.9350	.0253 *			
4.9820	.0192 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\pi \cdot \text{PHI} \times 45$	5 NANOSECOND PULSE	COHERENT RETURN
-1.6380	.0003 *			
-1.6110	.0005 *			
-1.5840	.0006 *			
-1.5570	.0009 *			
-1.5300	.0012 *			
-1.4230	.0016 *			
-1.3760	.0022 *			
-1.3290	.0030 *			
-1.2820	.0041 *			
-1.2350	.0055 *			
-1.1880	.0071 *			
-1.1410	.0088 *			
-1.0940	.0129 *			
-1.0470	.0170 *			
-1.0000	.0223 *			
-0.9530	.0282 *			
-0.9060	.0352 *			
-0.8590	.0431 *			
-0.8120	.0521 *			
-0.7650	.0620 *			
-0.7180	.0732 *			
-0.6720	.0853 *			
-0.6250	.0981 *			
-0.5800	.1115 *			
-0.5350	.1257 *			
-0.4900	.1403 *			
-0.4450	.1555 *			
-0.3970	.1708 *			
-0.3500	.1861 *			
-0.3040	.1988 *			
-0.2670	.2151 *			
-0.2300	.2320 *			
-0.1930	.2498 *			
-0.1560	.2676 *			
-0.1190	.2854 *			
-0.0820	.3032 *			
-0.0450	.3210 *			
-0.0080	.3388 *			
0.0330	.3465 *			
0.0660	.3543 *			
0.1000	.3620 *			
0.1330	.3697 *			
0.1660	.3774 *			
0.1990	.3851 *			
0.2320	.3928 *			
0.2650	.4005 *			
0.2980	.4082 *			
0.3310	.4160 *			
0.3640	.4237 *			
0.3970	.4304 *			
0.4300	.4371 *			
0.4630	.4438 *			
0.4960	.4506 *			
0.5290	.4574 *			
0.5620	.4642 *			
0.5950	.4710 *			
0.6280	.4778 *			
0.6610	.4846 *			
0.6940	.4914 *			
0.7270	.4982 *			
0.7600	.5050 *			
0.7930	.5118 *			
0.8260	.5186 *			
0.8590	.5254 *			
0.8920	.5322 *			
0.9250	.5390 *			
0.9580	.5458 *			
0.9910	.5526 *			
1.0240	.5594 *			
1.0570	.5662 *			
1.0900	.5730 *			
1.1230	.5797 *			
1.1560	.5865 *			
1.1890	.5933 *			
1.2220	.6001 *			
1.2550	.6069 *			
1.2880	.6137 *			
1.3210	.6205 *			
1.3540	.6273 *			
1.3870	.6341 *			
1.4200	.6409 *			
1.4530	.6477 *			
1.4860	.6545 *			
1.5190	.6613 *			
1.5520	.6681 *			
1.5850	.6749 *			
1.6180	.6817 *			
1.6510	.6885 *			
1.6840	.6953 *			
1.7170	.7021 *			
1.7500	.7089 *			
1.7830	.7157 *			
1.8160	.7225 *			
1.8490	.7293 *			
1.8820	.7361 *			
1.9150	.7429 *			
1.9480	.7497 *			
1.9810	.7565 *			
2.0140	.7633 *			
2.0470	.7701 *			
2.0800	.7769 *			
2.1130	.7837 *			
2.1460	.7905 *			
2.1790	.7973 *			
2.2120	.8041 *			
2.2450	.8109 *			
2.2780	.8177 *			
2.3110	.8245 *			
2.3440	.8313 *			
2.3770	.8381 *			
2.4100	.8449 *			
2.4430	.8517 *			
2.4760	.8585 *			
2.5090	.8653 *			
2.5420	.8721 *			
2.5750	.8789 *			
2.6080	.8857 *			
2.6410	.8925 *			
2.6740	.8993 *			
2.7070	.9061 *			
2.7400	.9129 *			
2.7730	.9197 *			
2.8060	.9265 *			
2.8390	.9333 *			
2.8720	.9391 *			
2.9050	.9459 *			
2.9380	.9527 *			
2.9710	.9595 *			
3.0040	.9663 *			
3.0370	.9731 *			
3.0700	.9799 *			
3.1030	.9867 *			
3.1360	.9935 *			
3.1690	.9993 *			
3.2020	.0051 *			
3.2350	.0119 *			
3.2680	.0187 *			
3.3010	.0255 *			
3.3340	.0323 *			
3.3670	.0391 *			
3.4000	.0459 *			
3.4330	.0527 *			
3.4660	.0595 *			
3.4990	.0663 *			
3.5320	.0731 *			
3.5650	.0800 *			
3.5980	.0868 *			
3.6310	.0936 *			
3.6640	.1004 *			
3.6970	.1072 *			
3.7300	.1140 *			
3.7630	.1208 *			
3.7960	.1276 *			
3.8290	.1344 *			
3.8620	.1412 *			
3.8950	.1480 *			
3.9280	.1548 *			
3.9610	.1616 *			
3.9940	.1684 *			
4.0270	.1752 *			
4.0600	.1820 *			
4.0930	.1888 *			
4.1260	.1956 *			
4.1590	.2024 *			
4.1920	.2092 *			
4.2250	.2160 *			
4.2580	.2228 *			
4.2910	.2296 *			
4.3240	.2364 *			
4.3570	.2432 *			
4.3900	.2500 *			
4.4230	.2568 *			
4.4560	.2636 *			
4.4890	.2704 *			
4.5220	.2772 *			
4.5550	.2840 *			
4.5880	.2908 *			
4.6210	.2976 *			
4.6540	.3044 *			
4.6870	.3112 *			
4.7200	.3180 *			
4.7530	.3248 *			
4.7860	.3316 *			
4.8190	.3384 *			
4.8520	.3452 *			
4.8850	.3520 *			
4.9180	.3588 *			
4.9510	.3656 *			
4.9840	.3724 *			
5.0170	.3792 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\theta = \text{PHI} = 45^\circ$	±2 NANOSECOND PULSE	INCOHERENT RETURN
1.4887	.0000 *			
1.4998	.0000 *			
1.5105	.0000 *			
1.5115	.0000 *			
1.5324	.0000 *			
1.5434	.0000 *			
1.5543	.0000 *			
1.5653	.0000 *			
1.5762	.0000 *			
1.5872	.0000 *			
1.5981	.0000 *			
1.6091	.0000 *			
1.6200	.0000 *			
1.6310	.0000 *			
1.6419	.0001 *			
1.6528	.0003 *			
1.6638	.0005 *			
1.6747	.0009 *			
1.6857	.0017 *			
1.6968	.0029 *			
1.7078	.0048 *			
1.7185	.0074 *			
1.7295	.0104 *			
1.7404	.0137 *			
1.7514	.0176 *			
1.7623	.0230 *			
1.7733	.0316 *			
1.7842	.0417 *			
1.7951	.0520 *			
1.8061	.0622 *			
1.8170	.0662 *			
1.8280	.1304 *			
1.8389	.1738 *			
1.8499	.2208 *			
1.8608	.2662 *			
1.8718	.3144 *			
1.8827	.3767 *			
1.8937	.4575 *			
1.9046	.5529 *			
1.9156	.6538 *			
1.9265	.7164 *			
1.9374	.8165 *			
1.9484	.9511 *			
1.9593	1.1146 *			
1.9703	1.2589 *			
1.9812	1.3921 *			
1.9922	1.5363 *			
2.0031	1.723 *	*		
2.0141	1.9438 *			
2.0250	2.1533 *			
2.0360	2.333 *			
2.0469	2.523 *			
2.0578	2.72 *			
2.0688	3.0775 *			
2.0797	3.3775 *			
2.0907	3.6476 *			
2.1016	3.9343 *			
2.1126	4.2929 *			
2.1235	4.7068 *			
2.1345	5.1111 *			
2.1454	5.4916 *			
2.1564	5.838 *			
2.1673	6.2261 *			
2.1783	7.0017 *			
2.1892	7.5660 *			
2.2001	8.1314 *			
2.2111	8.7720 *			
2.2220	9.5196 *			
2.2330	10.3337 *			
2.2439	11.2445 *			
2.2548	12.1579 *			
2.2658	13.2780 *			
2.2768	14.5288 *			
2.2877	15.8565 *			
2.2987	17.2731 *			
2.3096	18.8350 *			
2.3206	20.5624 *			
2.3315	22.4117 *			
2.3424	24.4005 *			
2.3534	26.5255 *	*		
2.3643	29.2341 *			
2.3753	31.9191 *			
2.3862	34.8160 *			
2.3972	37.8698 *			
2.4081	41.4272 *			
2.4191	45.2075 *			
2.4300	49.2716 *			
2.4410	53.4616 *			
2.4519	58.0672 *			
2.4629	64.7356 *			
2.4738	71.0948 *			
2.4847	78.3146 *			
2.4957	86.6614 *			
2.5068	96.5095 *			
2.5176	106.884 *			
2.5285	123.483 *			
2.5395	143.556 *			
2.5504	170.7339 *			
2.5614	207.3545 *			
2.5723	252.8724 *			
2.5833	300.2469 *			
2.5942	334.5570 *			
2.6052	338.2881 *			
2.6161	363.8813 *			
2.6270	394.1001 *			
2.6380	156.1370 *			
2.6489	88.3001 *			
2.6599	42.2090 *			
2.6708	16.9875 *			
2.6818	5.7402 *			
2.6927	1.6253 *			
2.7037	.31 *			
2.7146	.10762 *			
2.7256	.0126 *			
2.7365	.0017 *			
2.7474	.0002 *			
2.7584	.0000 *			
2.7693	.0000 *			
2.7803	.0000 *			
2.7912	.0000 *			
2.8022	.0000 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\omega$	PHI = 45°	+2 MICROSECOND PULSE	COHERENT RETURN
1.4887	.0000	*			
1.4996	.0000	*			
1.5105	.0000	*			
1.5215	.0000	*			
1.5324	.0000	*			
1.5434	.0000	*			
1.5543	.0000	*			
1.5653	.0000	*			
1.5762	.0000	*			
1.5872	.0000	*			
1.5981	.0000	*			
1.6091	.0000	*			
1.6200	.0000	*			
1.6310	.0001	*			
1.6419	.0002	*			
1.6528	.0004	*			
1.6638	.0006	*			
1.6747	.0013	*			
1.6857	.0017	*			
1.6966	.0015	*			
1.7076	.0029	*			
1.7185	.0044	*			
1.7295	.0017	*			
1.7404	.0005	*			
1.7514	.0015	*			
1.7623	.0021	*			
1.7733	.0044	*			
1.7842	.0056	*			
1.7951	.0074	*			
1.8061	.1207	*			
1.8170	.1819	*			
1.8280	.2503	*			
1.8389	.4294	*			
1.8499	.4960	*			
1.8608	.2401	*			
1.8718	.1752	*			
1.8827	.1543	*			
1.8937	.1980	*			
1.9046	.2675	*			
1.9156	.2990	*			
1.9265	.4451	*			
1.9374	.1872	*			
1.9484	.1106	*			
1.9593	.0871	*			
1.9703	.0983	*			
1.9812	.1704	*			
1.9922	.3429	*			
2.0031	.6558	*			
2.0141	.1406	*			
2.0250	.1402	*			
2.0360	.2024	*			
2.0469	.2.2102	*			
2.0579	.2.1592	*			
2.0688	.2.0189	*			
2.0797	.2.0008	*			
2.0907	.2.2427	*			
2.1016	.2.7566	*			
2.1126	.3.1204	*			
2.1235	.4.4586	*			
2.1345	.5.6007	*			
2.1454	.6.7955	*			
2.1564	.7.6469	*			
2.1673	.7.5837	*			
2.1783	.6.2796	*			
2.1892	.4.2005	*			
2.2001	.2.0004	*			
2.2111	.2.8409	*			
2.2220	.4.6494	*			
2.2330	.7.2336	*			
2.2439	.8.2117	*			
2.2549	.7.2858	*			
2.2658	.5.9021	*			
2.2768	.6.4634	*			
2.2877	.10.2530	*			
2.2987	.18.0405	*			
2.3096	.20.5920	*			
2.3206	.21.5678	*			
2.3315	.19.3177	*			
2.3424	.17.1172	*			
2.3534	.18.7478	*			
2.3643	.26.8481	*			
2.3753	.41.8324	*			
2.3862	.81.8344	*			
2.3972	.91.0174	*			
2.4081	.117.3242	*			
2.4191	.133.6489	*			
2.4300	.130.9705	*			
2.4410	.107.5504	*			
2.4519	.73.7838	*			
2.4629	.48.1510	*			
2.4738	.44.4958	*			
2.4847	.60.9677	*			
2.4957	.84.5214	*			
2.5066	.105.3812	*			
2.5176	.128.0800	*			
2.5285	.166.8315	*			
2.5395	.230.5451	*			
2.5504	.318.1548	*			
2.5614	.407.6062	*			
2.5723	.446.8142	*			
2.5833	.518.9620	*			
2.5942	.502.0230	*			
2.6052	.432.1441	*			
2.6161	.327.2550	*			
2.6270	.215.6840	*			
2.6380	.122.5933	*			
2.6489	.59.5901	*			
2.6598	.24.6352	*			
2.6708	.84.2211	*			
2.6818	.2.5446	*			
2.6927	.4.3116	*			
2.7037	.1.3116	*			
2.7146	.0.2320	*			
2.7256	.0.0314	*			
2.7365	.0.0004	*			
2.7474	.0.0000	*			
2.7584	.0.0000	*			
2.7693	.0.0000	*			
2.7803	.0.0000	*			
2.7912	.0.0000	*			
2.8022	.0.0000	*			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	X:	PHI = 45	*2 NANOSECOND PULSE	COMMENT RETURN
1.4887	.0000 *				
1.4996	.0000 *				
1.5105	.0000 *				
1.5215	.0000 *				
1.5324	.0000 *				
1.5434	.0000 *				
1.5543	.0000 *				
1.5653	.0000 *				
1.5762	.0000 *				
1.5872	.0000 *				
1.5981	.0000 *				
1.6091	.0000 *				
1.6200	.0000 *				
1.6310	.0001 *				
1.6419	.0001 *				
1.6528	.0006 *				
1.6638	.0013 *				
1.6747	.0024 *				
1.6857	.0046 *				
1.6966	.0081 *				
1.7076	.0135 *				
1.7185	.0204 *				
1.7295	.0281 *				
1.7404	.0354 *				
1.7514	.0414 *				
1.7623	.0488 *				
1.7733	.0685 *				
1.7842	.0552 *				
1.7951	.0565 *				
1.8061	.0850 *				
1.8170	.0877 *				
1.8280	.1274 *				
1.8389	.4067 *				
1.8499	.9551 *				
1.8608	1.3143 *				
1.8718	1.6205 *				
1.8827	1.8316 *				
1.8937	1.9635 *				
1.9046	1.9827 *				
1.9156	1.9846 *				
1.9265	1.9709 *				
1.9374	1.9361 *				
1.9484	1.8525 *				
1.9593	1.6947 *				
1.9703	1.4667 *				
1.9812	1.2088 *				
1.9921	.9955 *				
2.0031	.9888 *				
2.0141	.8663 *				
2.0250	.6209 *				
2.0360	.4838 *				
2.0469	.8715 *				
2.0579	1.1714 *				
2.0688	1.5249 *				
2.0797	1.8753 *				
2.0907	2.2285 *				
2.1016	2.6650 *				
2.1126	3.1306 *				
2.1235	3.6630 *				
2.1345	4.1111 *				
2.1454	4.5792 *				
2.1564	5.2171 *				
2.1673	6.2942 *				
2.1783	8.0847 *				
2.1892	10.7356 *				
2.2001	14.0500 *				
2.2111	17.3551 *				
2.2220	19.8878 *				
2.2330	20.4744 *				
2.2439	19.2087 *				
2.2549	16.9709 *				
2.2658	14.9396 *				
2.2768	13.8104 *				
2.2877	13.4467 *				
2.3087	13.2553 *				
2.3096	13.2783 *				
2.3205	10.4348 *				
2.3315	8.3978 *				
2.3426	7.5371 *				
2.3534	8.8656 *				
2.3643	12.0266 *				
2.3753	15.2463 *				
2.3862	16.6464 *				
2.3972	15.2054 *				
2.4081	15.5672 *				
2.4191	16.1437 *				
2.4300	23.3029 *				
2.4410	36.8938 *				
2.4519	55.7742 *				
2.4629	77.9926 *				
2.4738	102.1137 *				
2.4847	127.1277 *				
2.4957	155.0842 *				
2.5066	183.5755 *				
2.5176	209.8023 *				
2.5285	226.3862 *				
2.5395	224.5724 *				
2.5504	200.5153 *				
2.5614	160.2023 *				
2.5723	119.5555 *				
2.5833	83.4637 *				
2.5942	63.0966 *				
2.6052	51.0514 *				
2.6161	41.1166 *				
2.6270	30.3417 *				
2.6380	19.5667 *				
2.6489	10.7829 *				
2.6598	5.0381 *				
2.6708	1.0000 *				
2.6818	.6537 *				
2.6927	.1808 *				
2.7037	.0417 *				
2.7146	.0080 *				
2.7256	.0013 *				
2.7365	.0002 *				
2.7474	.0000 *				
2.7583	.0000 *				
2.7693	.0000 *				
2.7803	.0000 *				
2.7912	.0000 *				
2.8022	.0000 *				

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	$\phi = \text{PHI} = 45^\circ$	.2 NANOSECOND PULSE	COHERENT RETURN
1.4887	.0000 *			
1.4996	.0000 *			
1.5105	.0000 *			
1.5215	.0000 *			
1.5324	.0000 *			
1.5434	.0000 *			
1.5543	.0000 *			
1.5653	.0000 *			
1.5762	.0000 *			
1.5872	.0000 *			
1.5981	.0000 *			
1.6091	.0000 *			
1.6200	.0000 *			
1.6310	.0000 *			
1.6419	.0000 *			
1.6528	.0001 *			
1.6636	.0001 *			
1.6747	.0002 *			
1.6857	.0005 *			
1.6966	.0015 *			
1.7076	.0039 *			
1.7185	.0053 *			
1.7295	.0062 *			
1.7404	.0107 *			
1.7514	.0125 *			
1.7623	.0136 *			
1.7733	.0146 *			
1.7842	.0154 *			
1.7951	.0230 *			
1.8061	.0349 *			
1.8170	.0533 *			
1.8280	.0735 *			
1.8389	.0865 *			
1.8499	.0846 *			
1.8608	.0702 *			
1.8718	.073 *			
1.8827	.0534 *			
1.8937	.0703 *			
1.9046	.0843 *			
1.9156	.0873 *			
1.9265	.1060 *			
1.9374	.2106 *			
1.9484	.4774 *			
1.9593	.4474 *			
1.9703	.1534 *			
1.9812	.2184 *			
1.9922	.2732 *			
2.0031	.3.0784 *			
2.0141	.2.4335 *			
2.0250	.2.4037 *			
2.0360	.1.5787 *			
2.0469	.7664 *			
2.0578	.4070 *			
2.0688	.1269 *			
2.0797	.150 *			
2.0907	.1192 *			
2.1016	.0467 *			
2.1126	.0876 *			
2.1235	.2.966 *			
2.1345	.1.9100 *			
2.1454	.3021 *			
2.1564	.1.4346 *			
2.1673	.2.6270 *			
2.1783	.4.8676 *			
2.1892	.8.6026 *			
2.2001	13.9956 *			
2.2111	20.554 *			
2.2220	26.9048 *			
2.2330	31.2162 *			
2.2449	30.2311 *			
2.2558	3.4467 *			
2.2668	.29.4980 *			
2.2777	28.2541 *			
2.2887	28.1855 *			
2.2997	29.0175 *			
2.3096	30.6189 *			
2.3205	33.2631 *			
2.3315	37.3663 *			
2.3424	.4.9697 *			
2.3534	50.2306 *			
2.3643	.58.4442 *			
2.3753	.66.0583 *			
2.3862	.71.3223 *			
2.3972	.73.6381 *			
2.4081	.76.1851 *			
2.4191	.79.111 *			
2.4300	.79.129 *			
2.4410	.79.139 *			
2.4519	.80.6465 *			
2.4629	.83.5794 *			
2.4738	.87.2098 *			
2.4847	.88.8067 *			
2.4957	.76.7498 *			
2.5066	.62.6311 *			
2.5176	.44.4441 *			
2.5285	.32.1014 *			
2.5395	.35.5314 *			
2.5504	.06.9866 *			
2.5614	.142.0774 *			
2.5723	.270.2534 *			
2.5833	.436.0061 *			
2.5942	.586.9460 *			
2.6052	.636.1646 *			
2.6161	.431.15373 *			
2.6270	.499.61274 *			
2.6380	.331.1254 *			
2.6489	.183.5350 *			
2.6599	.85.1265 *			
2.6708	.33.0351 *			
2.6818	.10.7243 *			
2.6927	.2.49116 *			
2.7037	.1.124 *			
2.7146	.1.124 *			
2.7256	.0.0199 *			
2.7365	.0.026 *			
2.7474	.0.003 *			
2.7584	.0.000 *			
2.7693	.0.000 *			
2.7803	.0.000 *			
2.7912	.0.000 *			
2.8022	.0.000 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	x: PHI = 45	+2 NANOSECOND PULSE	COHERENT RETURN
1.4887	.0000 *			
1.4896	.0000 *			
1.5105	.0000 *			
1.5215	.0000 *			
1.5324	.0000 *			
1.5434	.0000 *			
1.5543	.0000 *			
1.5653	.0000 *			
1.5762	.0000 *			
1.5872	.0000 *			
1.5981	.0000 *			
1.6091	.0000 *			
1.6200	.0000 *			
1.6310	.0000 *			
1.6419	.0001 *			
1.6528	.0002 *			
1.6638	.0003 *			
1.6747	.0010 *			
1.6857	.0020 *			
1.6966	.0037 *			
1.7076	.0064 *			
1.7185	.0102 *			
1.7295	.0151 *			
1.7404	.0211 *			
1.7514	.0271 *			
1.7623	.0347 *			
1.7733	.0471 *			
1.7842	.0600 *			
1.7951	.0766 *			
1.8061	.0990 *			
1.8170	.1289 *			
1.8280	.1664 *			
1.8389	.2111 *			
1.8499	.2365 *			
1.8608	.2763 *			
1.8716	.3376 *			
1.8827	.4187 *			
1.8937	.4870 *			
1.9046	.5365 *			
1.9156	.5350 *			
1.9265	.4845 *			
1.9374	.4255 *			
1.9484	.1980 *			
1.9593	.4266 *			
1.9703	.5923 *			
1.9812	.8930 *			
1.9922	1.3248 *			
2.0031	1.7763 *			
2.0141	2.0414 *			
2.0250	2.0772 *			
2.0360	1.7018 *			
2.0469	1.2714 *			
2.0579	1.0853 *			
2.0688	1.4517 *			
2.0797	2.7669 *			
2.0907	5.1829 *			
2.1116	8.4175 *			
2.1226	11.8861 *			
2.1335	13.3534 *			
2.1345	15.1462 *			
2.1454	14.3819 *			
2.1563	12.8993 *			
2.1673	11.8090 *			
2.1783	10.9494 *			
2.1892	10.5920 *			
2.2001	9.7618 *			
2.2111	10.4461 *			
2.2220	11.9782 *			
2.2330	1.2767 *			
2.2439	2.6672 *			
2.2549	10.6759 *			
2.2658	25.0525 *			
2.2768	61.0943 *			
2.2877	61.2883 *			
2.2987	15.6760 *			
2.3096	8.9960 *			
2.3206	93.1498 *			
2.3315	91.0167 *			
2.3424	81.3155 *			
2.3533	65.7775 *			
2.3643	48.1865 *			
2.3753	32.9604 *			
2.3862	23.1740 *			
2.3972	18.5238 *			
2.4081	20.5865 *			
2.4191	24.7226 *			
2.4300	30.5607 *			
2.4410	37.1145 *			
2.4519	43.4361 *			
2.4629	46.1884 *			
2.4738	50.0593 *			
2.4847	41.1740 *			
2.4957	52.3526 *			
2.5066	66.0514 *			
2.5176	98.9332 *			
2.5285	155.4161 *			
2.5395	235.6908 *			
2.5504	336.8291 *			
2.5614	432.1707 *			
2.5723	517.0781 *			
2.5833	673.0706 *			
2.5942	726.0012 *			
2.6052	704.3449 *			
2.6161	603.2769 *			
2.6270	446.0648 *			
2.6380	286.8424 *			
2.6489	155.8808 *			
2.6598	71.1692 *			
2.6708	21.9895 *			
2.6818	8.0864 *			
2.6927	2.4432 *			
2.7037	.5557 *			
2.7146	.1057 *			
2.7256	.0168 *			
2.7365	.0022 *			
2.7474	.0002 *			
2.7583	.0000 *			
2.7692	.0000 *			
2.7803	.0000 *			
2.7912	.0000 *			
2.8022	.0000 *			

Figure 12. (Cont.)

POSITION (METERS)	INTENSITY	y: PHI = 45	+2 NANOSECOND PULSE	COHERENT RETURN
1.4887	.0000 *			
1.4996	.0000 *			
1.5105	.0000 *			
1.5215	.0000 *			
1.5324	.0000 *			
1.5434	.0000 *			
1.5543	.0000 *			
1.5653	.0000 *			
1.5762	.0000 *			
1.5872	.0000 *			
1.5981	.0000 *			
1.6091	.0000 *			
1.6200	.0000 *			
1.6310	.0000 *			
1.6419	.0000 *			
1.6528	.0001 *			
1.6638	.0003 *			
1.6747	.0005 *			
1.6857	.0008 *			
1.6966	.0013 *			
1.7075	.0019 *			
1.7185	.0022 *			
1.7295	.0019 *			
1.7404	.0009 *			
1.7514	.0000 *			
1.7623	.0018 *			
1.7733	.0100 *			
1.7842	.0285 *			
1.7951	.0606 *			
1.8061	.1067 *			
1.8170	.1811 *			
1.8280	.2693 *			
1.8389	.3557 *			
1.8499	.4057 *			
1.8608	.3790 *			
1.8718	.2748 *			
1.8827	.1411 *			
1.8937	.0751 *			
1.9046	.0107 *			
1.9156	.2543 *			
1.9265	.4771 *			
1.9374	.7350 *			
1.9484	.9817 *			
1.9593	1.1838 *			
1.9703	1.1515 *			
1.9812	1.0604 *			
1.9922	1.0899 *			
2.0031	2.0534 *			
2.0141	3.7848 *			
2.0250	4.4742 *			
2.0360	4.9579 *			
2.0469	5.3346 *			
2.0579	5.6602 *			
2.0688	5.9343 *			
2.0797	6.1928 *			
2.0907	6.4732 *			
2.1016	6.5597 *			
2.1126	4.3176 *			
2.1235	4.5691 *			
2.1345	4.6647 *			
2.1454	3.6359 *			
2.1564	2.0741 *			
2.1673	1.5776 *			
2.1783	1.7866 *			
2.1892	2.1564 *			
2.2001	7.2102 *			
2.2111	14.9099 *			
2.2220	24.7118 *			
2.2330	36.0599 *			
2.2439	41.5142 *			
2.2549	44.8119 *			
2.2658	44.6855 *			
2.2768	42.5886 *			
2.2877	42.4041 *			
2.2987	41.9863 *			
2.3096	41.4804 *			
2.3206	38.6516 *			
2.3315	32.4593 *			
2.3424	23.2173 *			
2.3534	15.1373 *			
2.3643	5.4167 *			
2.3753	2.4506 *			
2.3862	5.8999 *			
2.3972	14.7491 *			
2.4081	26.5340 *			
2.4191	39.0462 *			
2.4300	51.2530 *			
2.4410	44.1145 *			
2.4519	80.6916 *			
2.4629	102.0097 *			
2.4738	132.3201 *			
2.4847	175.2308 *			
2.4957	232.8298 *			
2.5066	303.1679 *			
2.5176	371.7762 *			
2.5285	44.1141 *			
2.5395	47.4361 *			
2.5504	48.4267 *			
2.5614	41.0405 *			
2.5723	329.0310 *			
2.5833	241.6187 *			
2.5942	164.9792 *			
2.6052	105.8307 *			
2.6161	63.1155 *			
2.6270	35.4167 *			
2.6380	17.7011 *			
2.6489	7.9401 *			
2.6599	3.1690 *			
2.6708	1.1273 *			
2.6818	.3382 *			
2.6927	.1013 *			
2.7037	.0253 *			
2.7146	.0015 *			
2.7256	.0010 *			
2.7365	.0002 *			
2.7474	.0000 *			
2.7584	.0000 *			
2.7693	.0000 *			
2.7803	.0000 *			
2.7912	.0000 *			
2.8022	.0000 *			

Figure 12. (Cont.)

## 10. ACCURACY OF THE RESULTS

The cube-corner specifications give a tolerance on the cube-corner dihedral-angle offset of  $0.5''$ . In addition, manufacturing errors, material inhomogeneities, or thermal gradients could cause deviations from the perfect optical performance computed by the transfer-function model used in this report. In order to estimate what the effect of these imperfections might be, we have made a set of runs in which the dihedral-angle offset has been varied from  $1.5''$  to  $2.5''$ . In addition to computing full gain and centroid range-correction matrices, the half-maximum and half-area range correction has been calculated at a few values of  $\theta_1$  and  $\theta_2$ .

Table 16 lists the average gain and centroid range correction in the 25- to 50- $\mu$ rad annulus as a function of dihedral-angle offset. The difference from the nominal  $2.0''$  values is listed in the columns headed  $\Delta_{\text{gain}}$  and  $\Delta_{\text{range}}$ . In the last two rows, instead of having all the offsets the same, we have used an equal mixture of the dihedral-angle offsets. This is an attempt to simulate the fact that the actual cube corners have some distribution of offsets within the given tolerance (the last entry would not actually be allowed by the specifications, since it includes  $3.0''$  offsets). The computations were done for a  $45^\circ$  angle of incidence on the satellite; this angle shows fairly pronounced variations of the range correction with velocity aberration (see Table 12j) and thus probably represents a suitable worst-case situation.

Table 16. Gain and centroid range correction vs. dihedral-angle offset. The incidence angle is  $45^\circ$ ;  $\Delta_{\text{gain}}$  and  $\Delta_{\text{range}}$  are the differences between the gain or range and the value for  $2.0''$ .

$\lambda$ (Å)	$\delta$	Gain $\times 10^7$	$\Delta_{\text{gain}}$ $\times 10^7$	Centroid range correction (m)	$\Delta_{\text{range}}$ (m)
5300	$1.5''$	8.8817	+0.4571	1.2659	-0.0012
5300	2.0	8.4246	0	1.2671	0
5300	2.5	4.9797	-3.4449	1.2556	-0.0115
6943	1.5	7.5060	+0.2621	1.2660	-0.0016
6943	2.0	7.2439	0	1.2676	0
6943	2.5	5.1599	-2.0840	1.2628	-0.0048
5300	$1.5, 2.0, 2.5$	7.5191	-0.9055	1.2661	-0.0010
5300	$2.0, 2.5, 3.0$	5.3068	-3.1178	1.2637	-0.0034

Tables 17 to 20 and Figures 13 and 14 give the complete details for the cases summarized in Table 16. In Table 18, the shift of the energy distribution from small to large values of velocity aberration as the dihedral-angle offset increases can be seen. Figure 13 illustrates the shift in more detail. The largest deviation of the centroid range correction between 25 and 50  $\mu$ rad occurs in Table 20c for  $\delta = 2.5'$  and  $\lambda = 5300 \text{ \AA}$ . At 25  $\mu$ rad, the average centroid range correction is 1.2089 m, which is 5.8 cm less than the nominal centroid range correction of 1.2671 m. Figure 14c shows that deviations of 8 cm occur at some spots; this is, of course, an extremely unlikely situation. The variation of the range correction within the far-field pattern is reduced when a mixture of offsets is used. For example, the deviation of the average centroid range correction at 25  $\mu$ rad for  $\lambda = 5300 \text{ \AA}$  is reduced from 1.6 cm for  $\delta = 2.0'$  (Table 20b) to 0.5 cm for a mixture of dihedral angles whose average is 2.0' (Table 20g). The corresponding maximum centroid range deviation is reduced from almost 3 cm (Figure 14b) to a little over 1 cm (Figure 14g). Considering that it is unlikely that all the dihedral-angle offsets are 2.5' and that some mixture of angles is certainly present, the maximum systematic error in the range correction is probably something between the values of 3 and 1 cm in Figures 14b and 14g.

To estimate the uncertainty in the range correction for other pulse-detection methods, we have performed computations for selected points in the far field and for two different dihedral-angle offsets. The data in Table 21 were computed for  $\lambda = 5300 \text{ \AA}$ ,  $\phi = 45^\circ$ , and a 0.2-nsec incident pulse. By using the reflectivity curve for  $\lambda = 5300 \text{ \AA}$  in Figure 7, the total range corrections for the three pulse-detection methods are as follows:

$$\begin{array}{ll} \text{centroid} & = 1.2669 \text{ m} \\ \text{half-maximum} & = 1.3030 \text{ m} \\ \text{half-area} & = 1.2855 \text{ m} . \end{array}$$

The columns headed  $\Delta$  give the difference between each value and the nominal values above.

Table 17. Gain-function matrices for various dihedral-angle offsets. The angles  $\theta_1$  and  $\theta_2$ , in microradians, are defined in Figure 8. Only half the matrix is presented since  $G(\theta_1, \theta_2) = G(-\theta_1, -\theta_2)$ .

$\theta_2$	GAIN FUNCTION (1.E+7)											
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	2.80	3.13	3.43	3.55	3.37	2.92	2.32	1.69	1.20	.93	.80	
45	5.65	6.12	6.46	6.33	5.60	4.60	3.65	2.75	1.91	1.32	1.02	
40	8.37	9.27	10.37	10.63	9.32	7.12	5.21	3.86	2.74	1.86	1.34	
35	9.36	10.95	13.44	15.02	13.91	10.66	7.40	5.18	3.64	2.49	1.77	
30	11.24	12.89	15.36	17.19	16.40	13.06	9.29	6.49	4.50	3.03	2.13	
25	16.47	17.30	17.81	17.65	15.89	12.73	9.57	7.13	5.12	3.45	2.34	
20	19.52	19.92	19.46	17.83	14.81	11.29	8.68	7.07	5.57	3.93	2.62	
15	15.01	15.81	16.54	16.40	14.17	10.65	8.12	7.10	6.15	4.63	3.12	
10	10.92	10.99	11.08	12.55	12.88	10.78	8.72	8.03	7.16	5.36	3.56	
5	15.63	12.89	8.48	8.77	11.17	11.33	10.40	9.92	8.49	5.84	3.64	
0	20.28	15.32	7.75	6.92	10.41	12.12	12.03	11.52	9.42	6.05	3.56	
-5	15.63	11.55	6.57	7.37	11.02	12.42	12.09	11.39	9.28	6.07	3.69	
-10	10.92	9.25	8.53	10.49	12.26	11.69	10.49	9.75	8.29	5.92	3.89	
-15	15.01	14.30	14.14	14.07	12.72	10.34	8.69	8.08	7.16	5.48	3.77	
-20	19.52	18.35	16.73	14.72	12.13	9.56	7.95	7.12	6.11	4.65	3.22	
-25	16.47	15.29	14.18	13.26	11.81	9.70	7.74	6.28	4.90	3.55	2.50	
-30	11.24	10.74	11.37	12.16	11.47	9.12	6.60	4.81	3.49	2.46	1.83	
-35	9.36	9.22	10.08	10.54	9.23	6.64	4.42	3.15	2.29	1.62	1.24	
-40	8.37	8.03	7.92	7.23	5.61	3.77	2.61	2.04	1.52	1.03	.77	
-45	5.65	5.20	4.65	3.85	2.89	2.11	1.68	1.34	.93	.60	.46	
-50	2.80	2.50	2.21	1.88	1.53	1.21	.94	.67	.45	.34	.31	

$\theta_2$	GAIN FUNCTION (1.E+7)											
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	7.25	7.87	8.31	8.48	8.24	7.57	6.43	4.98	3.58	2.56	1.92	
45	9.69	10.40	10.80	10.74	10.20	9.34	8.16	6.57	4.80	3.39	2.50	
40	11.40	12.23	12.87	12.82	11.78	10.31	8.98	7.55	5.82	4.24	3.13	
35	10.23	11.54	13.30	14.26	13.37	11.31	9.51	8.11	6.55	5.02	3.83	
30	7.56	9.19	11.70	13.61	13.42	11.59	9.83	8.50	7.04	5.55	4.38	
25	6.73	7.94	9.58	10.88	10.87	9.96	9.23	8.58	7.35	5.82	4.59	
20	6.90	7.45	7.88	7.93	7.46	7.18	7.67	8.14	7.54	6.13	4.75	
15	4.87	5.23	5.54	5.54	5.06	4.93	5.98	7.35	7.58	6.57	5.16	
10	2.90	2.91	2.88	3.42	3.79	4.05	5.23	6.89	7.47	6.78	5.58	
5	4.72	3.56	1.73	2.05	3.50	4.64	5.99	7.34	7.45	6.56	5.66	
0	6.71	4.57	1.53	1.73	4.03	5.95	7.40	8.23	7.62	6.35	5.63	
-5	4.72	3.00	1.19	2.25	4.78	6.66	7.99	8.66	7.97	6.68	5.90	
-10	2.90	2.26	2.24	3.64	5.28	6.45	7.72	8.75	8.56	7.46	6.33	
-15	4.87	4.59	4.73	5.21	5.62	6.31	7.76	9.13	9.17	7.96	6.37	
-20	6.90	6.37	6.12	6.19	6.41	7.12	8.48	9.52	9.16	7.66	5.94	
-25	6.73	6.19	6.52	7.38	7.98	8.32	8.84	9.06	8.22	6.72	5.30	
-30	7.56	7.21	8.01	9.02	9.05	8.36	7.94	7.64	6.77	5.56	4.51	
-35	10.23	9.73	9.75	9.47	8.31	6.96	6.37	6.11	5.37	4.37	3.49	
-40	11.40	10.53	9.50	8.13	6.58	5.52	5.21	4.92	4.11	3.13	2.36	
-45	9.69	8.72	7.54	6.26	5.19	4.57	4.23	3.66	2.76	1.94	1.40	
-50	7.25	6.50	5.63	4.75	3.97	3.36	2.79	2.14	1.49	1.02	.75	

Table 17. (Cont.)

c: PHI 45 DIHEDRAL ANGLE 2.50 WAVELENGTH 5300											
$\theta_2$	GAIN FUNCTION (1.E+7)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	9.08	9.57	9.69	9.64	9.50	9.20	8.51	7.36	6.11	5.10	4.24
45	8.45	9.01	9.23	9.26	9.23	9.15	8.77	7.86	6.69	5.73	4.93
40	7.72	8.13	8.24	8.12	7.88	7.81	7.89	7.64	6.97	6.26	5.53
35	5.70	6.14	6.60	6.81	6.52	6.26	6.58	7.00	6.99	6.73	6.19
30	2.98	3.58	4.50	5.21	5.18	5.02	5.55	6.37	6.79	6.89	6.65
25	1.65	2.11	2.73	3.27	3.42	3.76	4.81	5.93	6.42	6.52	6.47
20	1.74	1.86	1.84	1.76	1.79	2.52	4.07	5.49	5.99	5.92	5.78
15	1.50	1.50	1.31	1.04	.93	1.57	3.11	4.69	5.43	5.44	5.20
10	1.31	1.21	.87	.72	.70	1.06	2.20	3.66	4.62	4.98	4.96
5	2.58	2.00	.93	.66	.93	1.28	2.02	3.00	3.76	4.38	4.88
0	3.62	2.60	1.02	.78	1.43	1.98	2.46	2.93	3.32	4.03	5.01
-5	2.58	1.70	.69	.89	1.73	2.35	2.84	3.28	3.69	4.46	5.48
-10	1.31	.92	.69	1.06	1.67	2.30	3.20	4.19	4.92	5.55	6.09
-15	1.50	1.30	1.17	1.25	1.60	2.52	4.10	5.62	6.41	6.61	6.55
-20	1.74	1.47	1.30	1.45	2.02	3.32	5.27	6.86	7.39	7.24	6.96
-25	1.65	1.39	1.55	2.15	2.95	4.17	5.90	7.26	7.65	7.56	7.35
-30	2.98	2.73	2.92	3.34	3.71	4.41	5.78	7.03	7.50	7.53	7.27
-35	5.70	5.21	4.72	4.24	3.91	4.29	5.53	6.67	7.04	6.91	6.41
-40	7.72	6.88	5.74	4.65	4.09	4.46	5.47	6.17	6.13	5.71	5.06
-45	8.45	7.46	6.18	5.04	4.48	4.64	5.06	5.13	4.76	4.27	3.71
-50	9.08	8.10	6.77	5.47	4.58	4.17	3.98	3.69	3.32	2.96	2.54

d: PHI 45 DIHEDRAL ANGLE 1.50 WAVELENGTH 6943

$\theta_2$	GAIN FUNCTION (1.E+7)										
0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	2.66	2.98	3.53	4.10	4.34	4.02	3.22	2.31	1.62	1.21	.97
45	3.52	3.92	4.61	5.41	5.92	5.72	4.79	3.54	2.46	1.75	1.32
40	5.88	6.16	6.50	6.92	7.19	6.89	5.91	4.54	3.26	2.32	1.70
35	10.09	10.11	9.74	9.23	8.61	7.72	6.46	5.03	3.73	2.74	2.01
30	14.10	13.99	13.22	12.03	10.56	8.65	7.02	5.32	3.94	2.95	2.22
25	15.02	15.08	14.65	13.77	12.36	10.37	8.03	5.83	4.18	3.11	2.40
20	13.19	13.44	13.47	13.38	12.88	11.47	9.15	6.60	4.59	3.39	2.66
15	13.29	13.15	12.31	11.87	11.93	11.46	9.74	7.26	5.12	3.84	3.10
10	19.23	17.83	14.15	11.30	10.53	10.54	9.60	7.60	5.66	4.46	3.70
5	28.27	25.24	18.08	11.93	9.50	9.43	9.12	7.73	6.15	5.12	4.31
0	32.69	28.69	19.77	12.01	8.76	8.67	8.75	7.77	6.47	5.54	4.68
-5	28.27	24.57	16.91	10.55	8.22	8.50	8.66	7.70	6.41	5.47	4.61
-10	19.23	16.79	12.33	9.10	8.45	8.96	8.71	7.38	5.90	4.90	4.11
-15	13.29	12.12	10.46	9.60	9.69	9.63	8.53	6.69	5.05	4.05	3.39
-20	13.19	12.62	11.97	11.46	10.87	9.68	7.78	5.70	4.13	3.25	2.73
-25	15.02	14.45	13.47	12.19	10.60	8.68	6.59	4.74	3.45	2.71	2.26
-30	14.10	13.42	12.12	10.51	8.82	7.13	5.51	4.11	3.07	2.38	1.91
-35	10.09	9.51	8.58	7.61	6.75	5.86	4.83	3.73	2.77	2.05	1.54
-40	5.88	5.58	5.36	5.31	5.30	4.99	4.22	3.18	2.23	1.56	1.13
-45	3.52	3.44	3.65	4.03	4.26	4.01	3.23	2.26	1.47	1.00	.74
-50	2.66	2.63	2.83	3.06	3.07	2.67	1.97	1.26	.81	.60	.50

0 5 10 15 20 25 30 35 40 45 50  $\theta_1$

Table 17. (Cont.)

e: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

$\theta_2$	GAIN FUNCTION (1.E+7)											
50	5.31	5.79	6.50	7.15	7.33	6.78	5.68	4.46	3.45	2.72	2.12	
45	5.59	6.26	7.36	8.51	9.13	8.75	7.46	5.83	4.40	3.36	2.58	
40	6.32	7.02	8.11	9.31	10.04	9.80	8.55	6.82	5.21	3.97	3.03	
35	8.28	8.80	9.39	9.97	10.21	9.74	8.53	6.96	5.51	4.33	3.36	
30	10.54	10.82	10.88	10.70	10.19	9.20	7.84	6.44	5.28	4.37	3.56	
25	10.89	11.13	11.14	10.83	10.06	8.77	7.20	5.81	4.86	4.25	3.68	
20	8.67	9.02	9.35	9.56	9.33	8.39	6.90	5.49	4.62	4.21	3.86	
15	6.28	6.54	6.76	7.26	7.79	7.69	6.75	5.54	4.77	4.50	4.25	
10	6.69	6.39	5.45	5.23	5.98	6.72	6.60	5.90	5.38	5.20	4.89	
5	9.50	8.35	5.73	4.16	4.60	5.88	6.56	6.47	6.25	6.11	5.61	
0	11.15	9.42	5.89	3.62	3.92	5.53	6.70	7.00	6.96	6.79	6.10	
-5	9.50	7.86	4.92	3.31	4.01	5.75	6.91	7.18	7.09	6.86	6.12	
-10	6.69	5.64	4.20	3.89	5.01	6.40	7.01	6.86	6.57	6.29	5.67	
-15	6.28	5.78	5.47	5.84	6.65	7.12	6.85	6.19	5.71	5.46	5.04	
-20	8.67	8.34	8.17	8.16	8.03	7.45	6.46	5.52	4.99	4.77	4.47	
-25	10.89	10.45	9.88	9.23	8.39	7.31	6.14	5.19	4.65	4.36	4.02	
-30	10.54	10.00	9.33	8.64	7.94	7.09	6.12	5.23	4.57	4.07	3.55	
-35	8.28	7.84	7.56	7.49	7.42	7.04	6.24	5.24	4.33	3.61	2.96	
-40	6.32	6.06	6.25	6.73	7.06	6.82	5.92	4.72	3.67	2.89	2.28	
-45	5.59	5.45	5.75	6.21	6.38	5.90	4.83	3.64	2.71	2.10	1.66	
-50	5.31	5.15	5.23	5.30	5.05	4.34	3.35	2.44	1.85	1.50	1.22	
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$

f: PHI 45 DIHEDRAL ANGLE 2.50 WAVELENGTH 6943

$\theta_2$	GAIN FUNCTION (1.E+7)											
50	6.66	7.12	7.67	8.11	8.14	7.64	6.76	5.84	5.07	4.36	3.61	
45	6.01	6.65	7.59	8.53	8.99	8.64	7.64	6.47	5.49	4.71	3.95	
40	5.06	5.79	6.93	8.16	8.94	8.85	7.98	6.81	5.81	5.00	4.23	
35	4.79	5.43	6.34	7.33	8.00	7.99	7.36	6.51	5.77	5.13	4.43	
30	5.19	5.60	6.06	6.49	6.68	6.49	6.03	5.59	5.30	5.03	4.54	
25	5.10	5.35	5.54	5.61	5.46	5.06	4.63	4.46	4.58	4.72	4.55	
20	3.83	4.03	4.25	4.39	4.33	4.00	3.62	3.55	3.90	4.36	4.51	
15	2.38	2.52	2.65	2.91	3.19	3.23	3.08	3.11	3.56	4.18	4.50	
10	2.36	2.22	1.77	1.72	2.18	2.71	2.98	3.23	3.76	4.38	4.64	
5	3.69	3.11	1.81	1.13	1.57	2.51	3.26	3.81	4.41	4.91	4.93	
0	4.52	3.63	1.87	.90	1.39	2.64	3.73	4.49	5.10	5.44	5.21	
-5	3.69	2.85	1.43	.85	1.61	2.97	4.10	4.85	5.40	5.66	5.35	
-10	2.36	1.84	1.21	1.30	2.23	3.38	4.20	4.76	5.25	5.55	5.38	
-15	2.38	2.15	2.08	2.46	3.14	3.74	4.11	4.46	4.96	5.39	5.41	
-20	3.83	3.66	3.63	3.78	3.96	4.03	4.07	4.34	4.88	5.38	5.47	
-25	5.10	4.84	4.64	4.53	4.45	4.35	4.34	4.59	5.07	5.46	5.42	
-30	5.19	4.86	4.69	4.72	4.84	4.91	4.93	5.05	5.26	5.37	5.11	
-35	4.79	4.50	4.59	4.99	5.43	5.61	5.47	5.26	5.11	4.92	4.50	
-40	5.06	4.83	5.08	5.60	6.00	5.94	5.46	4.90	4.50	4.19	3.76	
-45	6.01	5.78	5.87	6.07	6.03	5.55	4.78	4.10	3.69	3.43	3.08	
-50	6.66	6.35	6.12	5.84	5.34	4.60	3.83	3.28	3.02	2.83	2.51	
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$

Table 17. (Cont.)

θ <sub>2</sub>	1.50										
	g:	PHI	45	DIHEDRAL ANGLE			2.00	WAVELFNGTH	5300		
				2.00	2.50	GAIN FUNCTION (1.E+7)					
50	6.18	6.83	7.19	7.23	6.95	6.40	5.58	4.53	3.48	2.66	2.11
45	7.69	8.41	8.83	8.77	8.25	7.50	6.65	5.53	4.23	3.18	2.51
40	8.90	9.85	10.73	10.85	9.85	8.36	7.16	6.09	4.85	3.71	2.92
35	8.18	9.61	11.60	12.74	11.82	9.57	7.65	6.42	5.30	4.26	3.47
30	7.07	8.60	10.93	12.67	12.25	10.09	8.02	6.70	5.62	4.68	4.00
25	8.35	9.23	10.29	10.96	10.37	8.87	7.62	6.80	5.86	4.89	4.23
20	9.68	10.01	10.03	9.48	8.23	7.02	6.68	6.70	6.15	5.13	4.28
15	7.21	7.63	8.11	8.14	7.16	5.98	5.94	6.63	6.58	5.59	4.46
10	4.66	4.72	4.98	6.06	6.45	5.63	5.93	6.89	7.06	6.01	4.69
5	7.13	5.61	3.45	4.18	5.90	6.36	6.76	7.62	7.43	6.04	4.73
0	9.76	7.00	3.13	3.47	5.97	7.18	7.69	8.17	7.45	5.83	4.70
-5	7.13	4.97	2.70	3.96	6.46	7.39	7.61	7.85	7.16	5.79	4.91
-10	4.66	3.94	4.01	5.64	6.87	6.76	6.72	7.16	6.98	6.09	5.25
-15	7.21	6.96	7.13	7.38	6.94	6.23	6.38	7.09	7.14	6.35	5.32
-20	9.68	9.09	8.47	7.90	7.24	6.84	7.13	7.54	7.19	6.17	5.07
-25	8.35	7.72	7.68	8.13	8.33	8.09	7.84	7.50	6.68	5.61	4.71
-30	7.07	6.73	7.56	8.76	8.98	8.12	7.20	6.54	5.75	4.92	4.26
-35	8.18	7.76	8.14	8.40	7.66	6.39	5.62	5.30	4.82	4.18	3.57
-40	8.90	8.14	7.47	6.57	5.41	4.56	4.40	4.37	3.94	3.29	2.68
-45	7.69	6.78	5.77	4.74	3.94	3.61	3.58	3.38	2.85	2.27	1.81
-50	6.18	5.35	4.48	3.70	3.13	2.79	2.50	2.12	1.70	1.37	1.12
	0	5	10	15	20	25	30	35	40	45	50 θ <sub>1</sub>

θ <sub>2</sub>	2.00										
	h:	PHI	45	DIHEDRAL ANGLE			2.50	3.00	WAVELENGTH	5300	
				2.50	3.00	GAIN FUNCTION (1.E+7)					
50	7.16	7.72	8.00	8.06	7.95	7.60	6.90	5.87	4.83	4.12	3.63
45	7.24	7.80	8.07	8.10	7.96	7.73	7.27	6.38	5.34	4.63	4.18
40	7.26	7.77	8.10	8.08	7.63	7.16	6.89	6.43	5.69	5.07	4.61
35	5.85	6.59	7.59	8.15	7.66	6.76	6.35	6.21	5.85	5.45	5.04
30	3.62	4.58	6.15	7.36	7.24	6.37	5.97	6.00	5.85	5.63	5.37
25	2.75	3.45	4.52	5.41	5.49	5.23	5.45	5.81	5.72	5.47	5.31
20	3.00	3.25	3.48	3.55	3.42	3.67	4.61	5.47	5.53	5.17	4.92
15	2.28	2.42	2.50	2.42	2.19	2.47	3.65	4.90	5.27	4.96	4.59
10	1.51	1.49	1.41	1.60	1.72	2.00	3.06	4.39	4.93	4.74	4.41
5	2.82	2.13	1.03	1.11	1.75	2.32	3.29	4.35	4.64	4.40	4.28
0	4.07	2.80	.98	1.01	2.11	3.00	3.88	4.58	4.51	4.23	4.37
-5	2.82	1.78	.68	1.17	2.35	3.19	4.00	4.68	4.74	4.63	4.84
-10	1.51	1.11	1.02	1.64	2.31	2.88	3.87	4.98	5.47	5.49	5.41
-15	2.28	2.11	2.10	2.23	2.38	2.96	4.33	5.76	6.35	6.16	5.72
-20	3.00	2.74	2.65	2.80	3.12	3.93	5.32	6.51	6.74	6.32	5.83
-25	2.75	2.54	2.95	3.78	4.45	5.05	5.91	6.57	6.54	6.20	5.94
-30	3.62	3.49	4.12	4.96	5.25	5.25	5.65	6.13	6.18	6.03	5.85
-35	5.85	5.51	5.46	5.33	4.90	4.69	5.19	5.80	5.88	5.64	5.27
-40	7.26	6.59	5.77	4.93	4.32	4.40	5.06	5.52	5.34	4.86	4.34
-45	7.24	6.41	5.43	4.58	4.18	4.34	4.70	4.70	4.29	3.81	3.38
-50	7.16	6.33	5.36	4.49	3.95	3.74	3.60	3.35	3.03	2.78	2.52
	0	5	10	15	20	25	30	35	40	45	50 θ <sub>1</sub>

Table 18. Gain function vs. velocity aberration for various dihedral-angle offsets. The average and rms deviations are computed around a circle in the far field whose radius is the velocity aberration listed, in microradians, in the first column.

b: PHI 45 DIHEDRAL ANGLE 1.50 WAVELENGTH 5300

AVERAGE GAIN FUNCTION (1.E+7)

0	20.28
5	14.66
10	9.63
15	11.08
20	14.57
25	14.38
30	12.29
35	10.90
40	9.11
45	6.31
50	3.84

R.M.S. FLUCTUATION

0	0.00 *
5	.45 *
10	1.36 *
15	2.92 *
20	3.31 *
25	2.36 *
30	2.18 *
35	2.38 *
40	1.90 *
45	1.17 *
50	.87 *

b: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300

AVERAGE GAIN FUNCTION (1.E+7)

0	6.71
5	4.30
10	2.33
15	3.25
20	5.18
25	6.29
30	7.62
35	9.25
40	9.57
45	8.41
50	6.87

R.M.S. FLUCTUATION

0	0.00 *
5	.19 *
10	.56 *
15	1.13 *
20	1.23 *
25	1.24 *
30	1.68 *
35	1.99 *
40	1.92 *
45	1.67 *
50	1.41 *

Table 18. (Cont.)

c: PHI 45 DIHEDRAL ANGLE 2.50 WAVELENGTH 5300

AVERAGE GAIN FUNCTION (1.E+7)

0	3.62	*
5	2.40	*
10	1.16	*
15	1.02	*
20	1.33	*
25	1.67	*
30	2.68	*
35	4.26	*
40	5.52	*
45	6.30	*
50	6.83	*

R.M.S. FLUCTUATION

0	0.00	*
5	.10	*
10	.15	*
15	.28	*
20	.31	*
25	.41	*
30	.56	*
35	.94	*
40	1.33	*
45	1.48	*
50	1.56	*

d: PHI 45 DIHEDRAL ANGLE 1.50 WAVELENGTH 6943

AVERAGE GAIN FUNCTION (1.E+7)

0	32.69	*
5	27.53	*
10	19.20	*
15	12.76	*
20	10.98	*
25	11.65	*
30	11.36	*
35	9.26	*
40	6.77	*
45	5.06	*
50	3.98	*

R.M.S. FLUCTUATION

0	0.00	*
5	.47	*
10	.65	*
15	.83	*
20	1.72	*
25	2.26	*
30	1.91	*
35	1.14	*
40	.86	*
45	.96	*
50	.90	*

Table 18. (Cont.)

e: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

AVERAGE GAIN FUNCTION (1.E+7)

0	11.15	*
5	9.11	*
10	6.26	*
15	5.06	*
20	6.26	*
25	8.04	*
30	8.56	*
35	7.85	*
40	7.00	*
45	6.48	*
50	5.87	*

R.M.S. FLUCTUATION

0	0.00 *
5	.19 *
10	.41 *
15	1.05 *
20	1.73 *
25	1.95 *
30	1.62 *
35	1.26 *
40	1.32 *
45	1.44 *
50	1.30 *

f: PHI 45 DIHEDRAL ANGLE 2.50 WAVELENGTH 6943

AVERAGE GAIN FUNCTION (1.E+7)

0	4.52	*
5	3.48	*
10	2.10	*
15	1.68	*
20	2.54	*
25	3.71	*
30	4.36	*
35	4.69	*
40	5.19	*
45	5.79	*
50	5.98	*

R.M.S. FLUCTUATION

0	0.00 *
5	.10 *
10	.23 *
15	.56 *
20	.88 *
25	.96 *
30	.87 *
35	.94 *
40	1.16 *
45	1.29 *
50	1.24 *

Table 18. (Cont.)

1.50  
 g: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300  
 2.50

AVERAGE GAIN FUNCTION (1.E+7)

0	9.76	*
5	6.62	
10	4.08	*
15	5.32	*
20	7.49	
25	7.78	*
30	7.74	*
35	8.37	
40	8.22	*
45	6.96	
50	5.67	*

R.M.S. FLUCTUATION

0	0.00 *
5	.23 *
10	.64 *
15	1.33 *
20	1.42 *
25	1.15 *
30	1.47 *
35	1.72 *
40	1.53 *
45	1.28 *
50	1.16 *

2.00  
 h: PHI 45 DIHEDRAL ANGLE 2.50 WAVELENGTH 5300  
 3.00

AVERAGE GAIN FUNCTION (1.E+7)

0	4.07	*
5	2.60	
10	1.29	*
15	1.57	*
20	2.34	
25	2.85	*
30	3.86	
35	5.25	*
40	5.94	
45	5.94	*
50	5.88	*

R.M.S. FLUCTUATION

0	0.00 *
5	.12 *
10	.24 *
15	.47 *
20	.48 *
25	.54 *
30	.81 *
35	.98 *
40	1.08 *
45	1.15 *
50	1.18 *

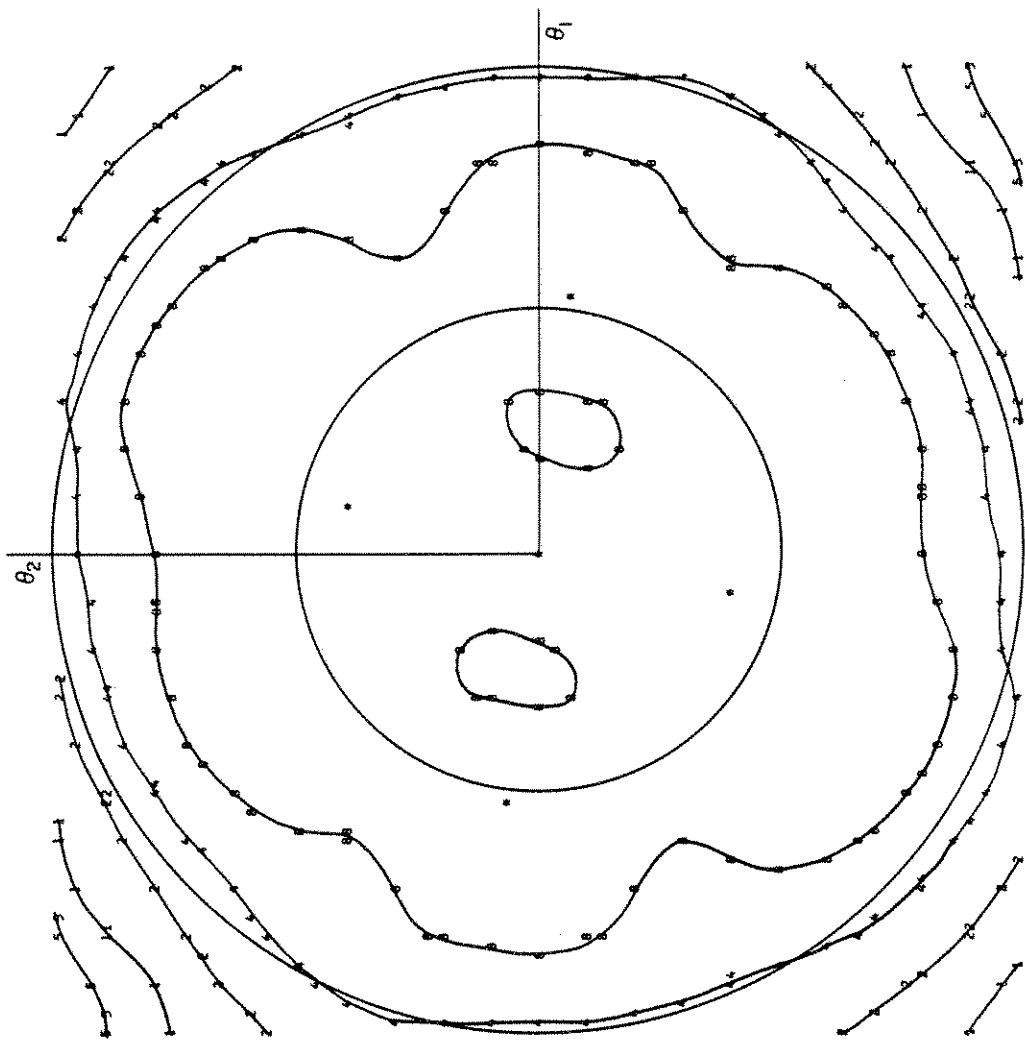


Figure 13. Contour plots of the gain-function matrices given in Table 17. Circles of radius 25 and 50  $\mu\text{rad}$  are shown to mark the minimum and maximum values of velocity aberration. The numbers are the gain function in units of  $10^7$ . The contour levels are plotted at 8, 4, 2, 1, and  $0.5 \times 10^7$ . a:  $\phi = 45^\circ$ ,  $\delta = 115$ ,  $\lambda = 5300 \text{ \AA}$ .

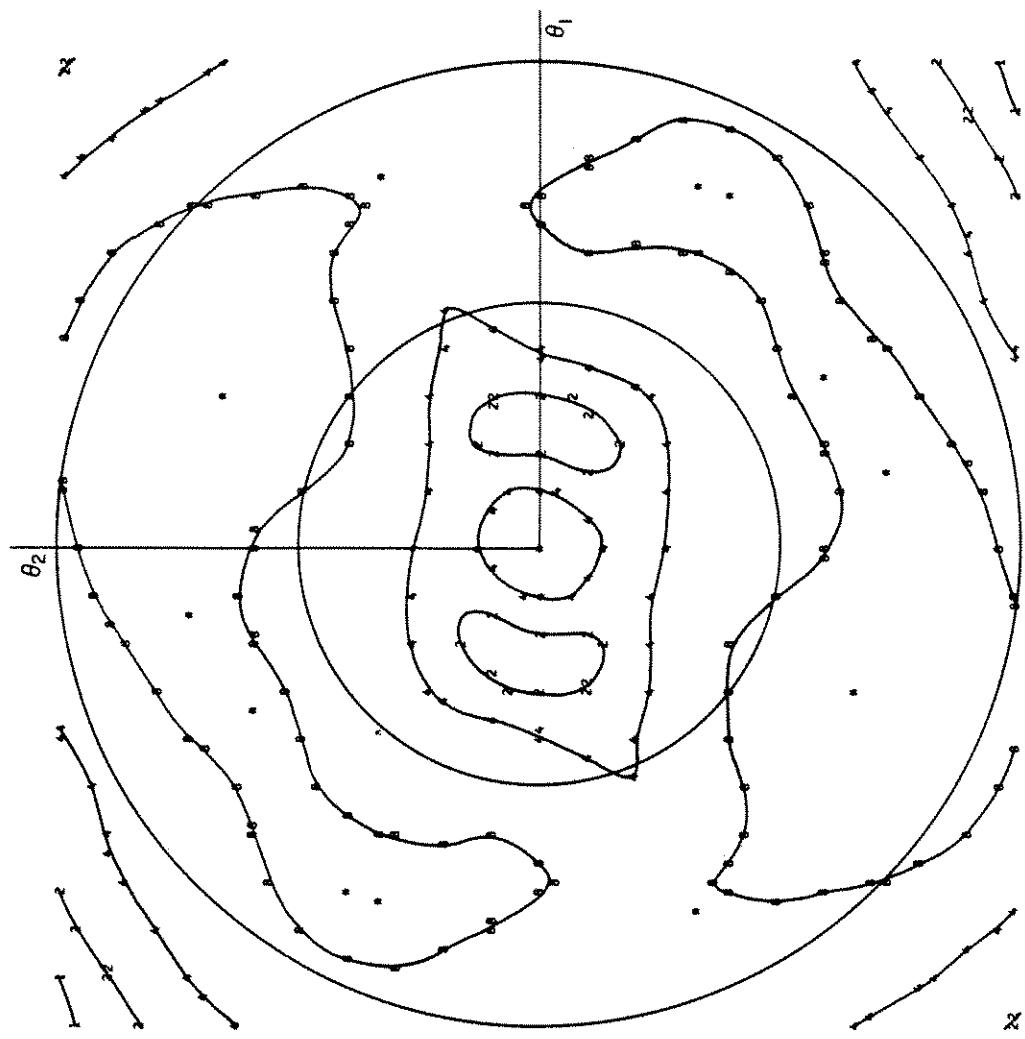


Figure 13b:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0'$ ,  $\lambda = 5300 \text{ \AA}$ .

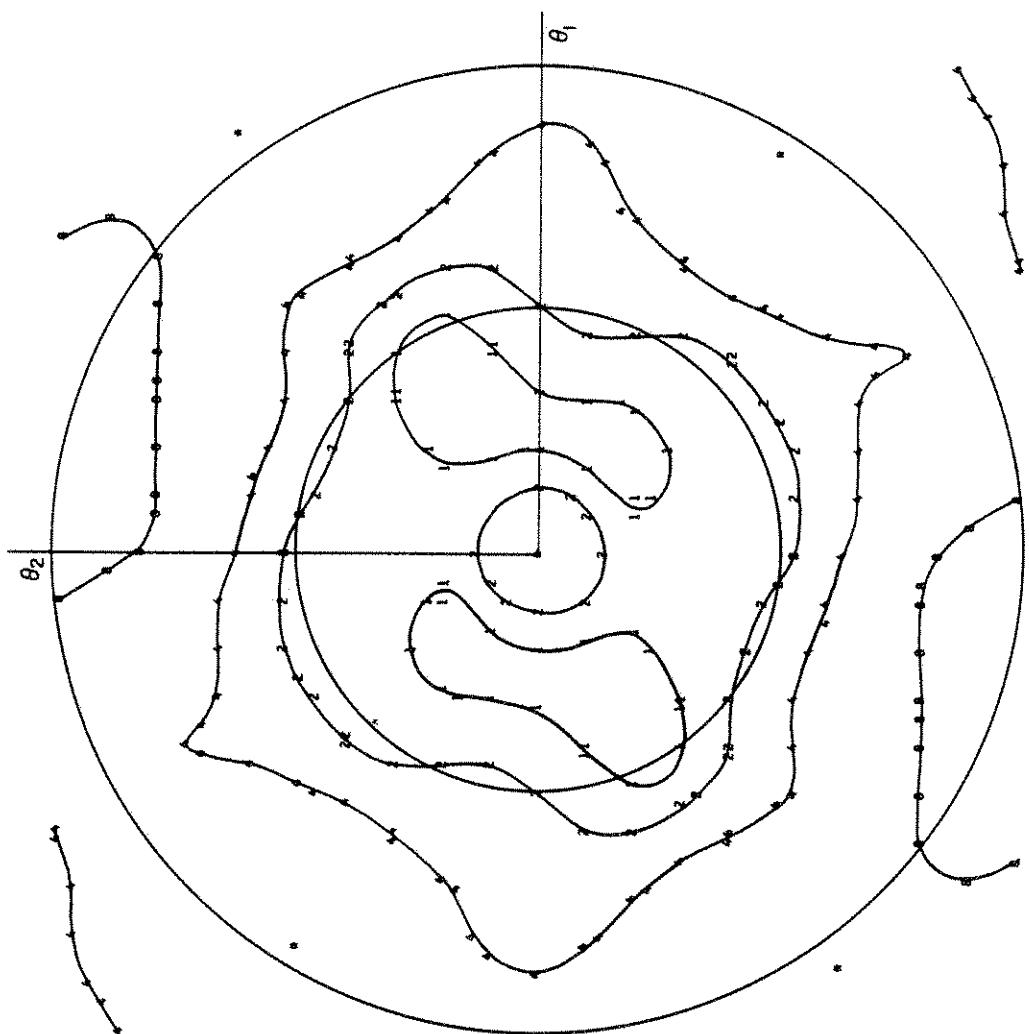


Figure 13c:  $\phi = 45^\circ$ ,  $\delta = 215^\circ$ ,  $\lambda = 5300 \text{ \AA}$ .

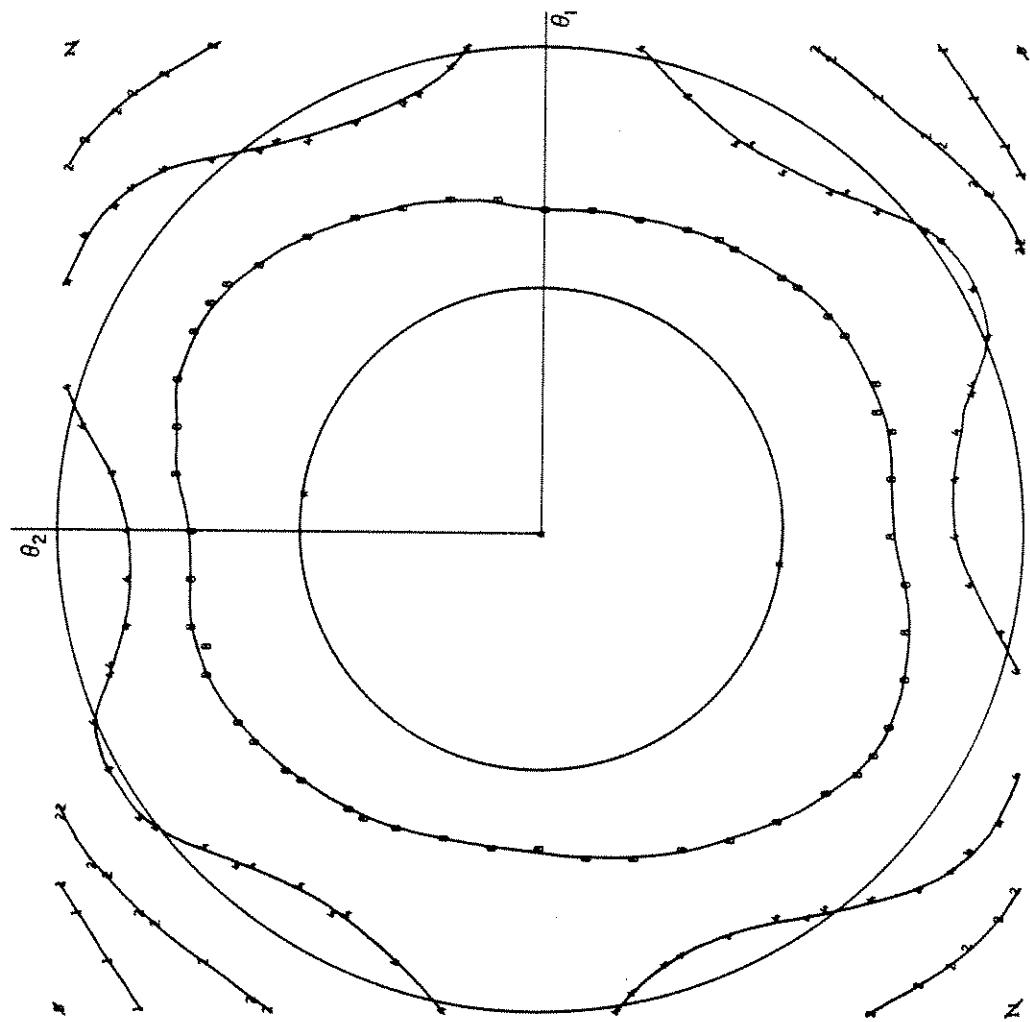


Figure 13d:  $\phi = 45^\circ$ ,  $\delta = 1.5$ ,  $\lambda = 6943 \text{ \AA}$ .

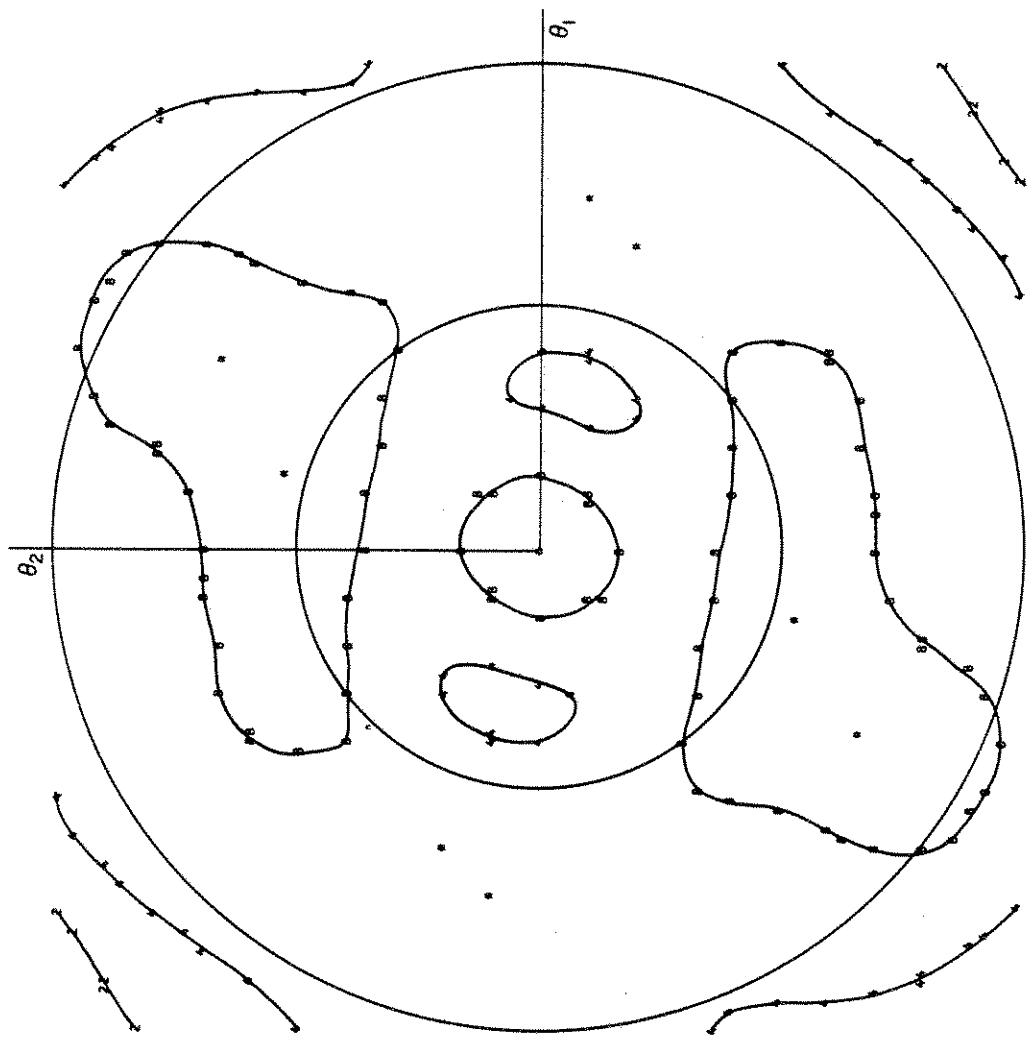


Figure 13e:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0'$ ,  $\lambda = 6943 \text{ \AA}$ .

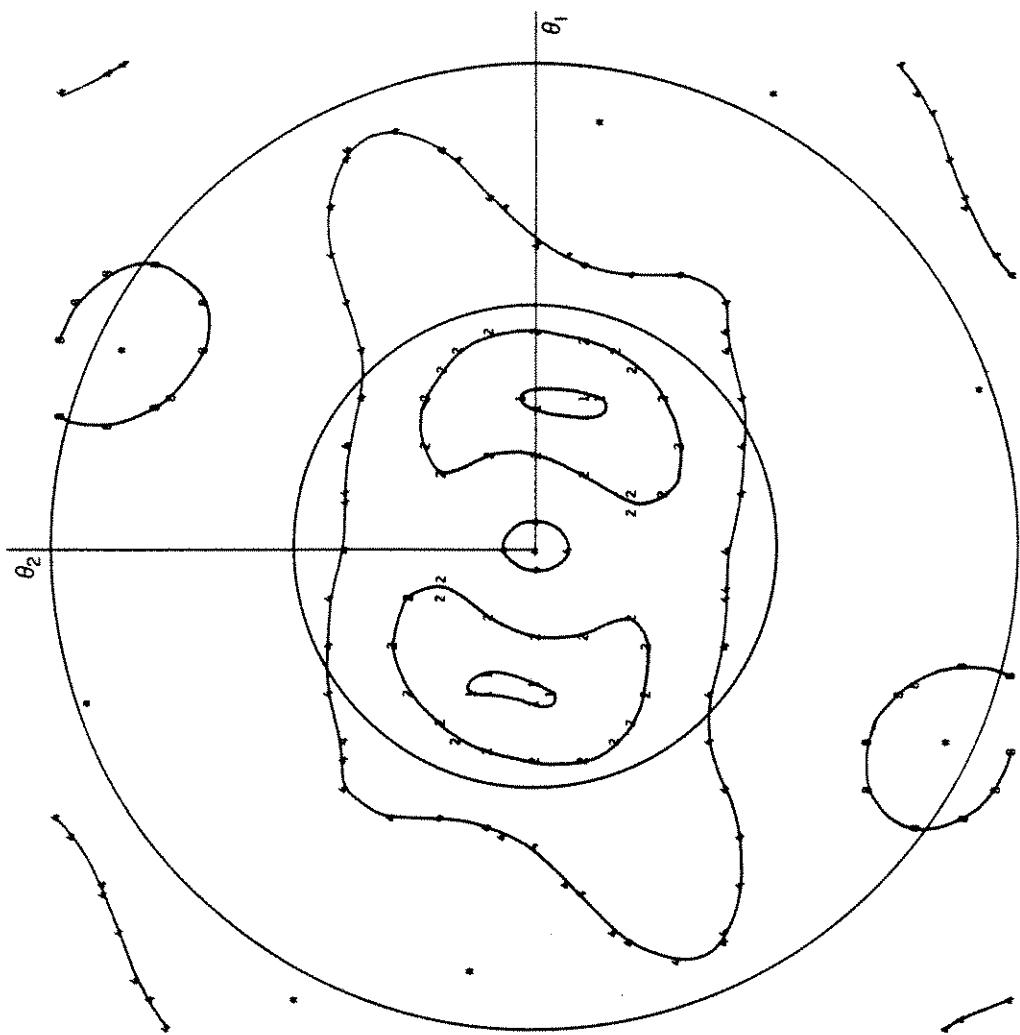


Figure 13f:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 5'$ ,  $\lambda = 6943 \text{ \AA}$ .

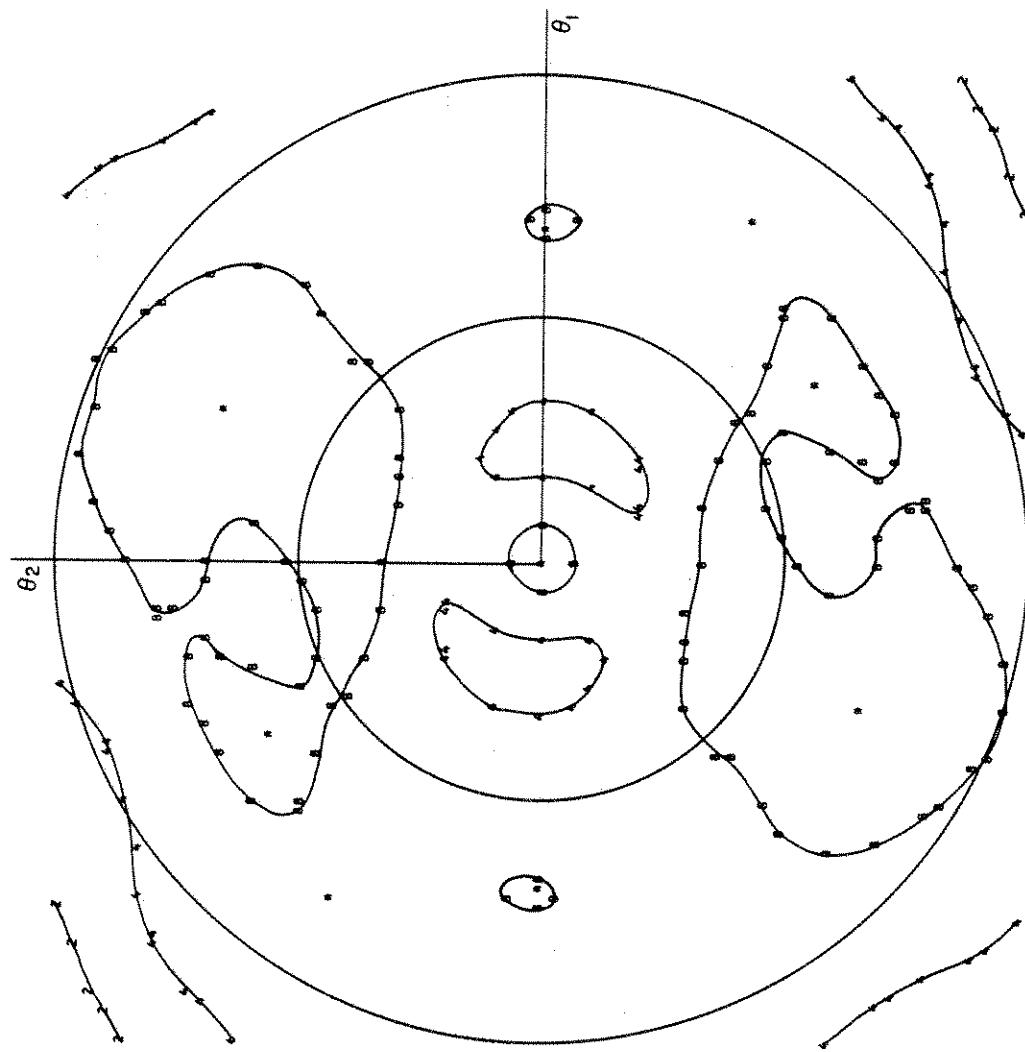


Figure 13g:  $\phi = 45^\circ$ ,  $\delta = 1^\circ 15'$ ,  $2^\circ 0'$ ,  $2^\circ 5'$ ,  $\lambda = 5300 \text{ \AA}$ .

Table 19. (Cont.)

		DIHEDRAL ANGLE 2.50 WAVELENGTH 5300											
		RANGE CORRECTION (METERS)											
$\theta_2$		0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.271	1.267	1.263	1.261	1.259	1.257	1.255	1.251	1.250	1.250	1.250	1.250	
45	1.267	1.264	1.260	1.257	1.257	1.258	1.257	1.255	1.255	1.255	1.257	1.257	
40	1.263	1.259	1.254	1.251	1.250	1.252	1.257	1.260	1.261	1.263	1.265	1.265	
35	1.255	1.251	1.248	1.247	1.245	1.246	1.254	1.262	1.267	1.271	1.274	1.274	
30	1.230	1.233	1.239	1.245	1.245	1.246	1.256	1.266	1.273	1.277	1.279	1.279	
25	1.195	1.208	1.222	1.233	1.238	1.247	1.262	1.273	1.277	1.280	1.281	1.281	
20	1.207	1.207	1.204	1.203	1.212	1.243	1.268	1.278	1.279	1.279	1.278	1.278	
15	1.202	1.198	1.187	1.171	1.172	1.230	1.266	1.276	1.276	1.273	1.272	1.272	
10	1.202	1.190	1.161	1.153	1.161	1.207	1.251	1.265	1.267	1.267	1.267	1.267	
5	1.251	1.238	1.184	1.159	1.197	1.215	1.237	1.252	1.257	1.261	1.266	1.266	
0	1.264	1.254	1.202	1.181	1.224	1.232	1.238	1.245	1.250	1.259	1.269	1.269	
-5	1.251	1.235	1.164	1.192	1.229	1.233	1.239	1.247	1.255	1.265	1.273	1.273	
-10	1.202	1.177	1.154	1.201	1.222	1.231	1.246	1.259	1.267	1.272	1.275	1.275	
-15	1.202	1.197	1.196	1.205	1.219	1.243	1.262	1.271	1.274	1.274	1.274	1.274	
-20	1.207	1.200	1.197	1.212	1.236	1.258	1.271	1.275	1.275	1.274	1.274	1.274	
-25	1.195	1.189	1.209	1.237	1.252	1.263	1.271	1.274	1.274	1.274	1.275	1.275	
-30	1.230	1.233	1.243	1.252	1.256	1.261	1.268	1.273	1.274	1.276	1.277	1.277	
-35	1.255	1.257	1.258	1.257	1.256	1.261	1.270	1.275	1.277	1.278	1.278	1.278	
-40	1.263	1.265	1.264	1.263	1.264	1.270	1.277	1.279	1.279	1.279	1.277	1.277	
-45	1.267	1.270	1.270	1.271	1.274	1.278	1.281	1.281	1.279	1.278	1.277	1.277	
-50	1.271	1.273	1.275	1.276	1.277	1.279	1.279	1.278	1.277	1.277	1.277	1.277	

		DIHEDRAL ANGLE 1.50 WAVELENGTH 6943											
		RANGE CORRECTION (METERS)											
$\theta_2$		0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.261	1.263	1.266	1.270	1.271	1.269	1.263	1.251	1.235	1.221	1.212	1.212	
45	1.260	1.261	1.266	1.271	1.273	1.273	1.269	1.259	1.245	1.230	1.218	1.218	
40	1.264	1.264	1.265	1.268	1.270	1.270	1.267	1.260	1.249	1.236	1.224	1.224	
35	1.269	1.269	1.267	1.266	1.265	1.264	1.261	1.255	1.246	1.237	1.228	1.228	
30	1.272	1.271	1.269	1.267	1.264	1.260	1.255	1.248	1.240	1.234	1.229	1.229	
25	1.270	1.269	1.268	1.267	1.265	1.261	1.255	1.246	1.238	1.233	1.231	1.231	
20	1.261	1.261	1.262	1.264	1.266	1.265	1.261	1.252	1.243	1.238	1.239	1.239	
15	1.254	1.253	1.253	1.257	1.263	1.267	1.266	1.261	1.253	1.250	1.252	1.252	
10	1.259	1.257	1.251	1.249	1.257	1.267	1.270	1.269	1.265	1.264	1.266	1.266	
5	1.266	1.264	1.255	1.246	1.251	1.265	1.273	1.275	1.274	1.275	1.276	1.276	
0	1.269	1.266	1.258	1.247	1.249	1.266	1.276	1.279	1.279	1.279	1.280	1.280	
-5	1.266	1.264	1.256	1.246	1.252	1.269	1.278	1.279	1.278	1.277	1.277	1.277	
-10	1.259	1.257	1.251	1.249	1.261	1.273	1.278	1.276	1.272	1.270	1.270	1.270	
-15	1.254	1.254	1.254	1.260	1.269	1.275	1.275	1.270	1.263	1.259	1.259	1.259	
-20	1.261	1.263	1.265	1.269	1.272	1.272	1.269	1.262	1.253	1.249	1.250	1.250	
-25	1.270	1.270	1.271	1.270	1.268	1.263	1.256	1.249	1.246	1.246	1.246	1.246	
-30	1.272	1.272	1.270	1.269	1.267	1.265	1.262	1.258	1.253	1.250	1.248	1.248	
-35	1.269	1.269	1.268	1.267	1.268	1.269	1.269	1.266	1.261	1.255	1.248	1.248	
-40	1.264	1.264	1.266	1.269	1.274	1.276	1.276	1.272	1.264	1.253	1.243	1.243	
-45	1.260	1.262	1.268	1.274	1.279	1.281	1.278	1.270	1.258	1.243	1.232	1.232	
-50	1.261	1.264	1.270	1.276	1.278	1.278	1.272	1.259	1.240	1.228	1.224	1.224	

Table 19. (Cont.)

e: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 6943

$\theta_2$	RANGE CORRECTION (METERS)										
50	1.266	1.266	1.267	1.269	1.270	1.268	1.263	1.257	1.250	1.243	1.237
45	1.263	1.264	1.267	1.271	1.273	1.272	1.269	1.262	1.254	1.247	1.240
40	1.260	1.261	1.265	1.269	1.272	1.272	1.270	1.264	1.258	1.251	1.244
35	1.261	1.262	1.264	1.266	1.268	1.268	1.266	1.262	1.258	1.253	1.249
30	1.264	1.263	1.263	1.263	1.263	1.262	1.260	1.257	1.255	1.254	1.253
25	1.262	1.262	1.262	1.262	1.261	1.258	1.255	1.251	1.251	1.254	1.257
20	1.253	1.253	1.255	1.258	1.260	1.259	1.256	1.252	1.252	1.257	1.262
15	1.236	1.237	1.241	1.250	1.258	1.262	1.261	1.259	1.260	1.265	1.269
10	1.236	1.233	1.227	1.235	1.253	1.265	1.269	1.269	1.271	1.275	1.277
5	1.251	1.245	1.230	1.223	1.247	1.268	1.276	1.277	1.279	1.281	1.282
0	1.256	1.251	1.233	1.218	1.246	1.271	1.279	1.281	1.282	1.283	1.283
-5	1.251	1.245	1.228	1.220	1.252	1.274	1.279	1.280	1.279	1.280	1.280
-10	1.236	1.231	1.224	1.237	1.262	1.274	1.276	1.275	1.274	1.274	1.275
-15	1.236	1.237	1.243	1.256	1.267	1.272	1.271	1.268	1.267	1.268	1.269
-20	1.253	1.255	1.259	1.264	1.268	1.268	1.266	1.263	1.262	1.265	1.267
-25	1.262	1.263	1.264	1.266	1.267	1.267	1.265	1.264	1.264	1.267	1.267
-30	1.264	1.264	1.265	1.266	1.268	1.270	1.270	1.270	1.270	1.270	1.269
-35	1.261	1.262	1.264	1.269	1.273	1.276	1.277	1.276	1.274	1.271	1.268
-40	1.260	1.262	1.267	1.273	1.279	1.281	1.281	1.278	1.274	1.269	1.264
-45	1.263	1.265	1.271	1.277	1.281	1.282	1.280	1.275	1.270	1.264	1.260
-50	1.266	1.269	1.273	1.276	1.278	1.278	1.275	1.269	1.264	1.261	1.258
	0	5	10	15	20	25	30	35	40	45	50 $\theta_1$

f: PHI 45 DIHEDRAL ANGLE 2.50 WAVELENGTH 6943

$\theta_2$	RANGE CORRECTION (METERS)										
50	1.267	1.266	1.266	1.266	1.265	1.264	1.261	1.258	1.257	1.255	1.253
45	1.262	1.262	1.264	1.267	1.268	1.267	1.264	1.261	1.258	1.257	1.255
40	1.254	1.256	1.261	1.265	1.268	1.268	1.266	1.263	1.261	1.259	1.258
35	1.248	1.250	1.256	1.261	1.265	1.266	1.265	1.264	1.263	1.263	1.263
30	1.248	1.249	1.252	1.255	1.258	1.259	1.260	1.261	1.264	1.267	1.268
25	1.246	1.246	1.247	1.249	1.250	1.250	1.251	1.256	1.263	1.269	1.272
20	1.233	1.234	1.237	1.242	1.244	1.245	1.245	1.252	1.262	1.271	1.275
15	1.205	1.207	1.213	1.226	1.239	1.245	1.248	1.254	1.265	1.273	1.277
10	1.213	1.205	1.188	1.197	1.230	1.249	1.257	1.263	1.270	1.276	1.278
5	1.245	1.235	1.201	1.169	1.222	1.256	1.267	1.271	1.275	1.279	1.279
0	1.254	1.246	1.211	1.155	1.224	1.262	1.271	1.274	1.276	1.278	1.278
-5	1.245	1.235	1.192	1.157	1.235	1.264	1.270	1.271	1.273	1.275	1.276
-10	1.213	1.199	1.171	1.200	1.247	1.263	1.266	1.266	1.269	1.272	1.273
-15	1.205	1.205	1.214	1.236	1.253	1.259	1.260	1.262	1.266	1.270	1.273
-20	1.233	1.235	1.241	1.249	1.255	1.258	1.259	1.262	1.267	1.272	1.274
-25	1.246	1.247	1.249	1.253	1.258	1.261	1.264	1.268	1.273	1.276	1.276
-30	1.248	1.248	1.251	1.257	1.264	1.269	1.272	1.275	1.277	1.278	1.277
-35	1.248	1.249	1.256	1.264	1.272	1.276	1.278	1.278	1.277	1.277	1.275
-40	1.254	1.257	1.264	1.271	1.277	1.279	1.279	1.277	1.276	1.275	1.273
-45	1.262	1.265	1.270	1.274	1.277	1.278	1.276	1.274	1.274	1.273	1.273
-50	1.267	1.269	1.272	1.274	1.275	1.275	1.273	1.274	1.275	1.274	1.274
	0	5	10	15	20	25	30	35	40	45	50 $\theta_1$

Table 19. (Cont.)

1.50  
 g: PHI 45 DIHEDRAL ANGLE 2.00 WAVELENGTH 5300  
 2.50

$\theta_2$	RANGE CORRECTION (METERS)											
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.266	1.264	1.262	1.261	1.259	1.258	1.255	1.250	1.242	1.236	1.233	
45	1.265	1.263	1.261	1.259	1.257	1.256	1.255	1.252	1.246	1.239	1.238	
40	1.264	1.263	1.262	1.261	1.259	1.255	1.253	1.252	1.249	1.245	1.244	
35	1.259	1.260	1.264	1.267	1.265	1.259	1.254	1.253	1.252	1.252	1.253	
30	1.252	1.256	1.263	1.268	1.267	1.263	1.258	1.257	1.257	1.258	1.260	
25	1.255	1.256	1.259	1.262	1.262	1.260	1.259	1.262	1.263	1.264	1.264	
20	1.258	1.257	1.257	1.256	1.253	1.251	1.257	1.265	1.268	1.267	1.266	
15	1.245	1.246	1.250	1.254	1.252	1.249	1.256	1.267	1.271	1.269	1.265	
10	1.221	1.220	1.230	1.251	1.259	1.258	1.262	1.270	1.273	1.270	1.265	
5	1.247	1.234	1.211	1.243	1.267	1.270	1.272	1.276	1.276	1.271	1.266	
0	1.260	1.248	1.210	1.241	1.271	1.275	1.275	1.277	1.276	1.270	1.267	
-5	1.247	1.233	1.206	1.252	1.272	1.273	1.271	1.273	1.272	1.269	1.268	
-10	1.221	1.218	1.236	1.263	1.270	1.266	1.265	1.268	1.269	1.268	1.267	
-15	1.245	1.249	1.258	1.266	1.267	1.263	1.265	1.269	1.270	1.268	1.265	
-20	1.258	1.259	1.262	1.266	1.268	1.270	1.272	1.274	1.272	1.267	1.263	
-25	1.255	1.256	1.262	1.270	1.275	1.277	1.276	1.275	1.271	1.266	1.263	
-30	1.252	1.255	1.266	1.275	1.279	1.278	1.275	1.273	1.270	1.267	1.266	
-35	1.259	1.262	1.270	1.275	1.276	1.274	1.272	1.272	1.271	1.270	1.268	
-40	1.264	1.266	1.269	1.271	1.270	1.270	1.272	1.274	1.273	1.271	1.269	
-45	1.265	1.266	1.268	1.269	1.270	1.273	1.276	1.276	1.273	1.270	1.267	
-50	1.266	1.267	1.269	1.271	1.274	1.276	1.276	1.272	1.268	1.266	1.266	

2.00  
 h: PHI 45 DIHEDRAL ANGLE 2.50 WAVELENGTH 5300  
 3.00

$\theta_2$	RANGE CORRECTION (METERS)											
	0	5	10	15	20	25	30	35	40	45	50	$\theta_1$
50	1.267	1.264	1.261	1.259	1.258	1.257	1.255	1.251	1.247	1.246	1.249	
45	1.266	1.263	1.259	1.257	1.256	1.257	1.257	1.255	1.252	1.252	1.256	
40	1.265	1.261	1.258	1.255	1.253	1.253	1.256	1.258	1.258	1.259	1.263	
35	1.258	1.256	1.257	1.258	1.256	1.253	1.255	1.260	1.263	1.266	1.269	
30	1.241	1.246	1.255	1.261	1.261	1.258	1.259	1.264	1.268	1.271	1.274	
25	1.227	1.235	1.247	1.255	1.257	1.258	1.264	1.270	1.273	1.274	1.275	
20	1.233	1.233	1.236	1.239	1.241	1.251	1.266	1.275	1.276	1.275	1.273	
15	1.217	1.217	1.220	1.223	1.222	1.238	1.262	1.274	1.275	1.273	1.270	
10	1.191	1.184	1.184	1.209	1.222	1.235	1.258	1.270	1.272	1.269	1.267	
5	1.246	1.228	1.167	1.195	1.236	1.249	1.261	1.269	1.269	1.267	1.267	
0	1.263	1.249	1.179	1.199	1.248	1.257	1.264	1.269	1.268	1.266	1.269	
-5	1.246	1.225	1.140	1.215	1.250	1.255	1.260	1.266	1.268	1.269	1.271	
-10	1.191	1.173	1.185	1.233	1.246	1.248	1.258	1.267	1.270	1.271	1.272	
-15	1.217	1.221	1.233	1.244	1.247	1.254	1.266	1.273	1.274	1.272	1.271	
-20	1.233	1.234	1.242	1.253	1.261	1.268	1.274	1.276	1.274	1.271	1.270	
-25	1.227	1.231	1.250	1.266	1.273	1.274	1.275	1.275	1.272	1.270	1.271	
-30	1.241	1.248	1.263	1.272	1.275	1.273	1.273	1.273	1.272	1.272	1.273	
-35	1.258	1.263	1.268	1.272	1.271	1.270	1.272	1.275	1.275	1.275	1.274	
-40	1.265	1.267	1.269	1.270	1.270	1.273	1.276	1.278	1.277	1.276	1.274	
-45	1.266	1.268	1.270	1.271	1.274	1.277	1.279	1.279	1.277	1.276	1.274	
-50	1.267	1.269	1.271	1.273	1.275	1.277	1.277	1.276	1.275	1.276	1.276	

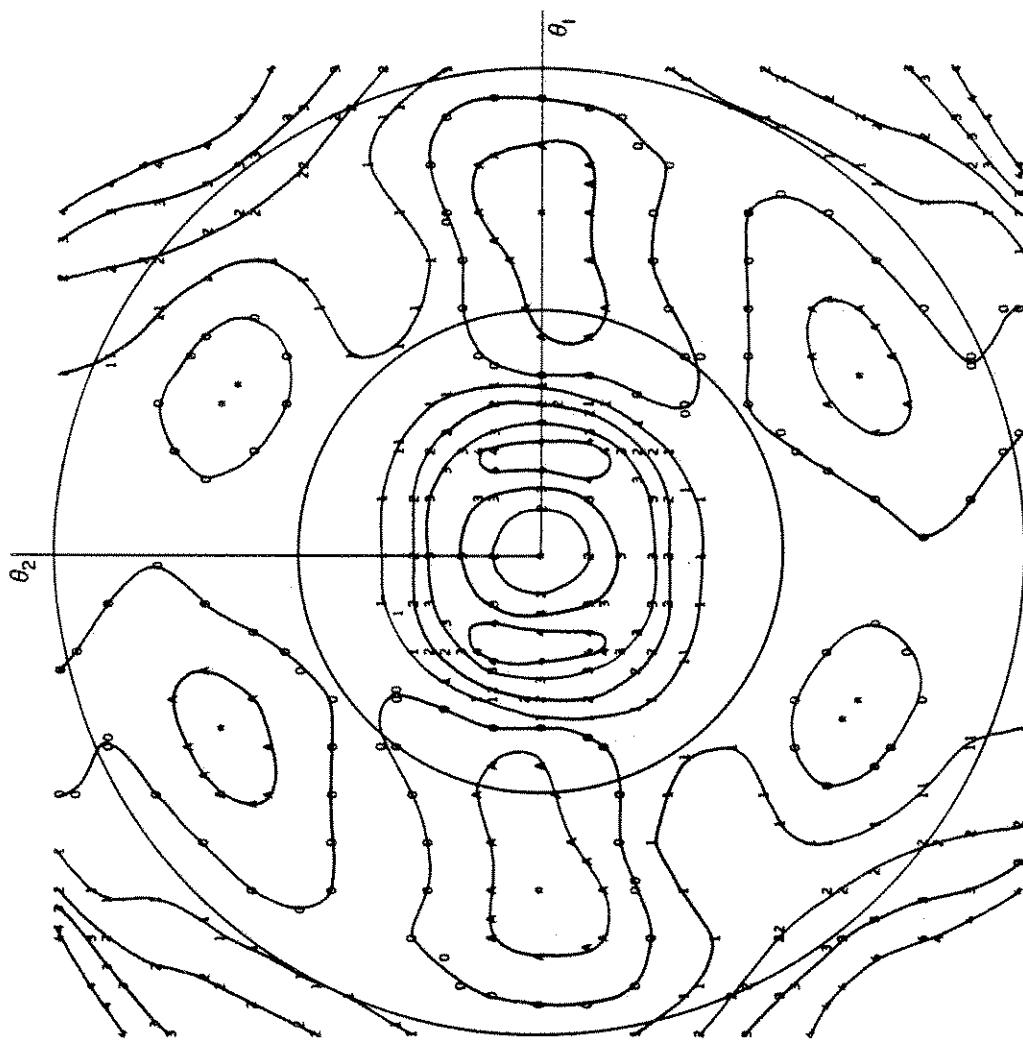
0      5      10     15     20     25     30     35     40     45     50      $\theta_1$

Table 20. Centroid range correction vs. velocity aberration for various dihedral-angle offsets. The average and rms deviations are computed around a circle in the far field whose radius is the velocity aberration listed, in microradians, in the first column.

a:	PHI	45	DIHEDRAL ANGLE	1.50	WAVELENGTH	5300	b:	PHI	45	DIHEDRAL ANGLE	2.00	WAVELENGTH	5300
							AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)
0	1.2561						0	1.2570					*
5	1.2447						5	1.2347					*
10	1.2298						10	1.1811					*
15	1.2476						15	1.2113					*
20	1.2645						20	1.2425					*
25	1.2669						25	1.2599					*
30	1.2661						30	1.2599					*
35	1.2685						35	1.2683					*
40	1.2694						40	1.2708					*
45	1.2699						45	1.2699					*
50	1.2577						50	1.2694					*
R.M.S. FLUCTUATION													
0	0.0000	*					0	0.0000	*				R.M.S. FLUCTUATION
5	*.0012	*					5	*.0031	*				
10	*.0048	*					10	*.0138	*				
15	*.0032	*					15	*.0076	*				
20	*.0048	*					20	*.0082	*				
25	*.0061	*					25	*.0082	*				
30	*.0069	*					30	*.0066	*				
35	*.0081	*					35	*.0052	*				
40	*.0076	*					40	*.0052	*				
45	*.0068	*					45	*.0056	*				
50	*.0078	*					50	*.0060	*				
R.M.S. FLUCTUATION													
c:	PHI	45	DIHEDRAL ANGLE	2.50	WAVELENGTH	5300	d:	PHI	45	DIHEDRAL ANGLE	1.50	WAVELENGTH	6943
AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)						AVERAGE RANGE CORRECTION (METERS)	
0	1.2643						0	1.2687					*
5	1.2479						5	1.2655					*
10	1.1950						10	1.2580					*
15	1.1811						15	1.2510					*
20	1.1986						20	1.2561					*
25	1.2089						25	1.2665					*
30	1.2362						30	1.2708					*
35	1.2544						35	1.2690					*
40	1.2612						40	1.2651					*
45	1.2658						45	1.2631					*
50	1.2699						50	1.2631					*
R.M.S. FLUCTUATION													
0	0.0000	*					0	0.0000	*				R.M.S. FLUCTUATION
5	*.0024	*					5	*.0083	*				
10	*.0058	*					10	*.0086	*				
15	*.0134	*					15	*.0027	*				
20	*.0180	*					20	*.0041	*				
25	*.0157	*					25	*.0025	*				
30	*.0060	*					30	*.0034	*				
35	*.0077	*					35	*.0047	*				
40	*.0090	*					40	*.0062	*				
45	*.0079	*					45	*.0097	*				
50	*.0068	*					50	*.0127	*				

Table 20. (Cont.)

Figure 14. Contour plots of the centroid range-correction matrices given in Table 19. Circles of radius 25 and 50  $\mu$ rad are shown to mark the minimum and maximum values of the velocity aberration. The symbol B represents a centroid range correction minus the average centroid range correction in the 25- to 50- $\mu$ rad annulus equal to +2 cm; A equals +1 cm; 0 equals 0 cm; and 1 through 8 equal -1 through -8 cm. a:  $\phi = 45^\circ$ ,  $\delta = 1.5^\circ$ ,  $\lambda = 5300 \text{ \AA}$ .



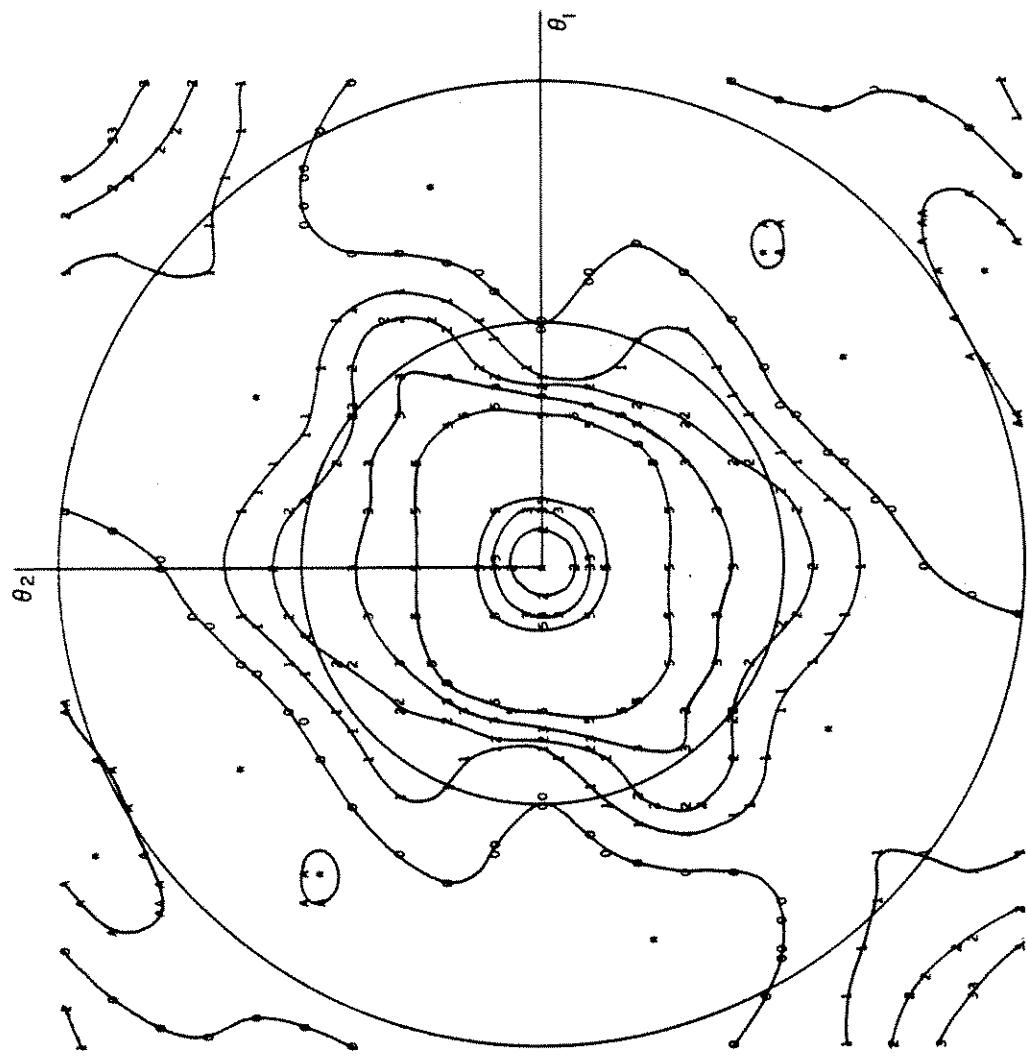


Figure 14b:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0$ ,  $\lambda = 5300 \text{ \AA}$ .

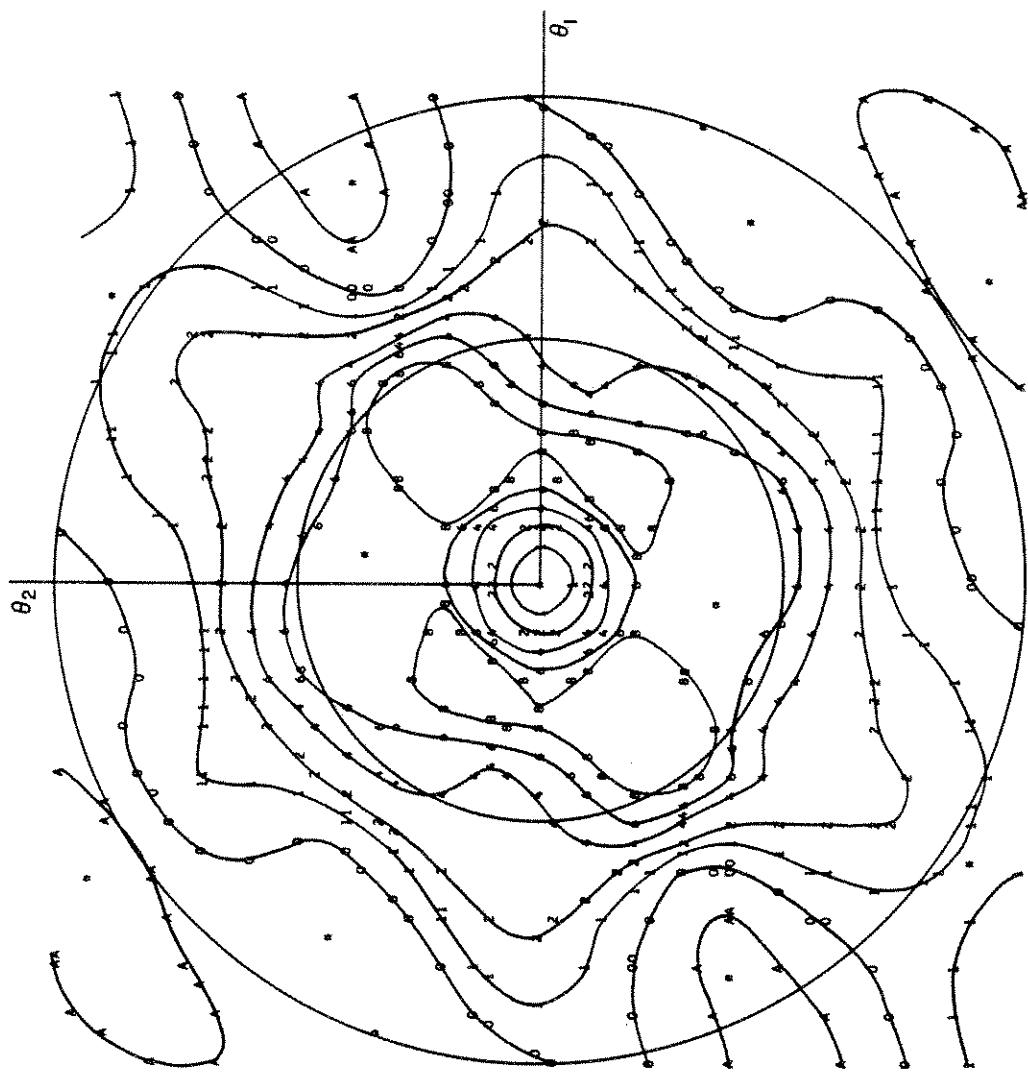


Figure 14c:  $\phi = 45^\circ$ ,  $\delta = 215$ ,  $\lambda = 5300 \text{ \AA}$ .

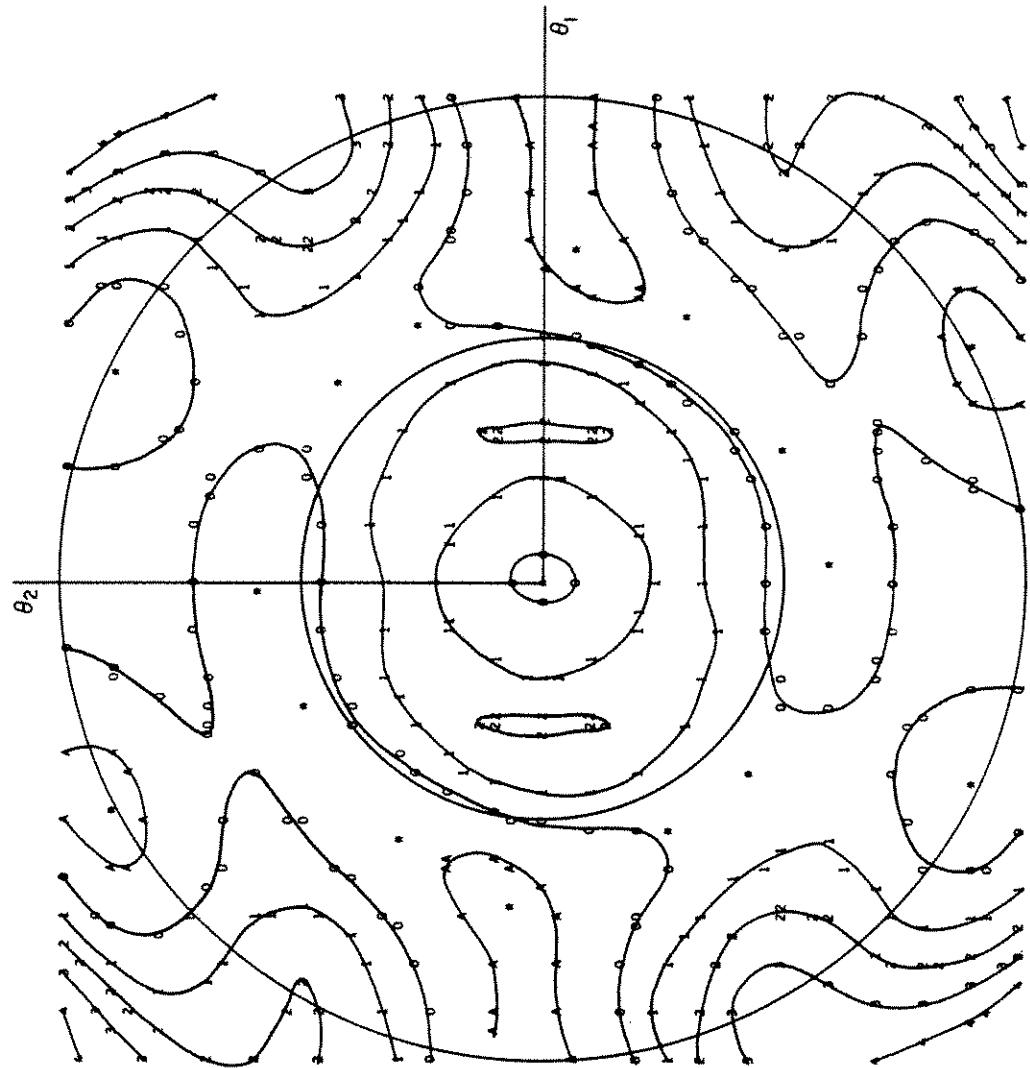


Figure 14d:  $\phi = 45^\circ$ ,  $\delta = 1.5$ ,  $\lambda = 6943 \text{ \AA}$ .

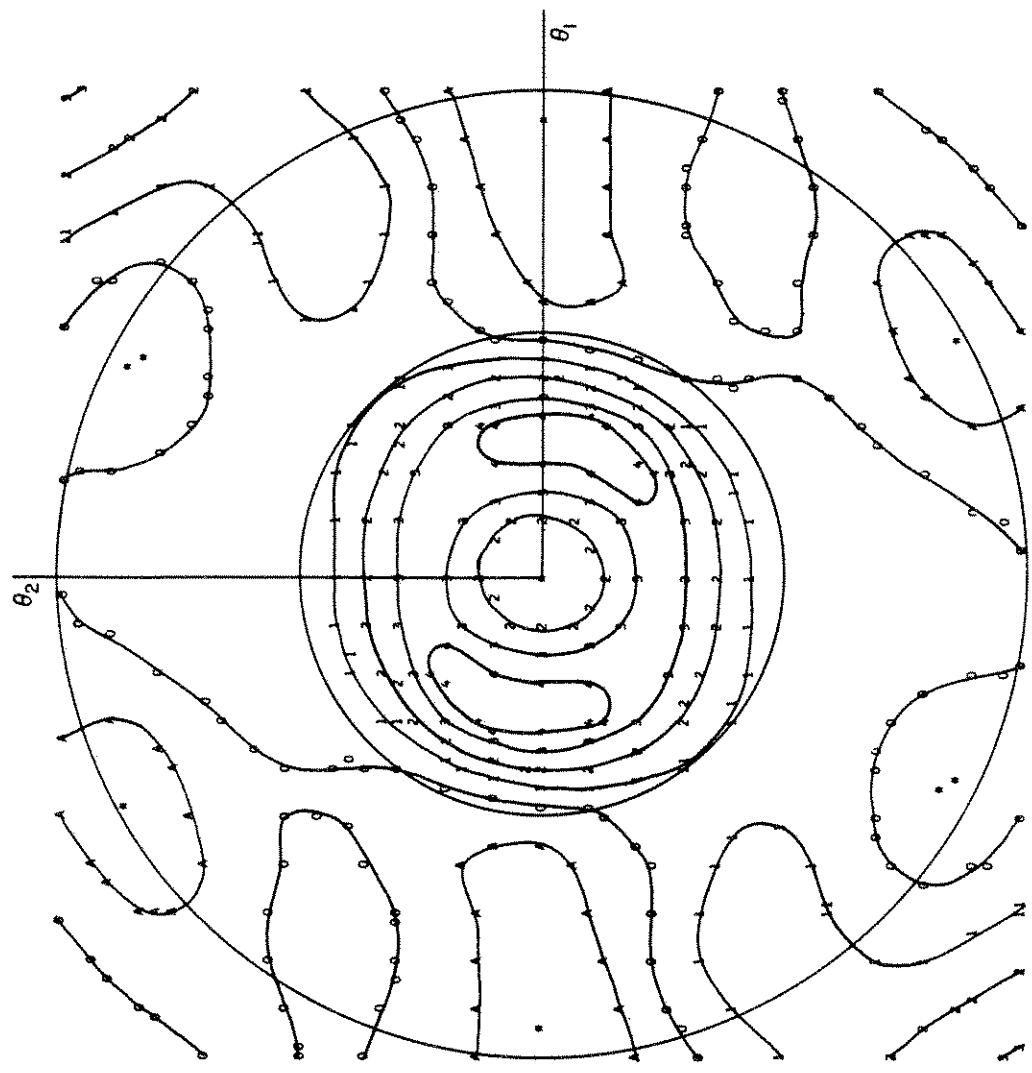


Figure 14e:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0'$ ,  $\lambda = 6943 \text{ \AA}$ .

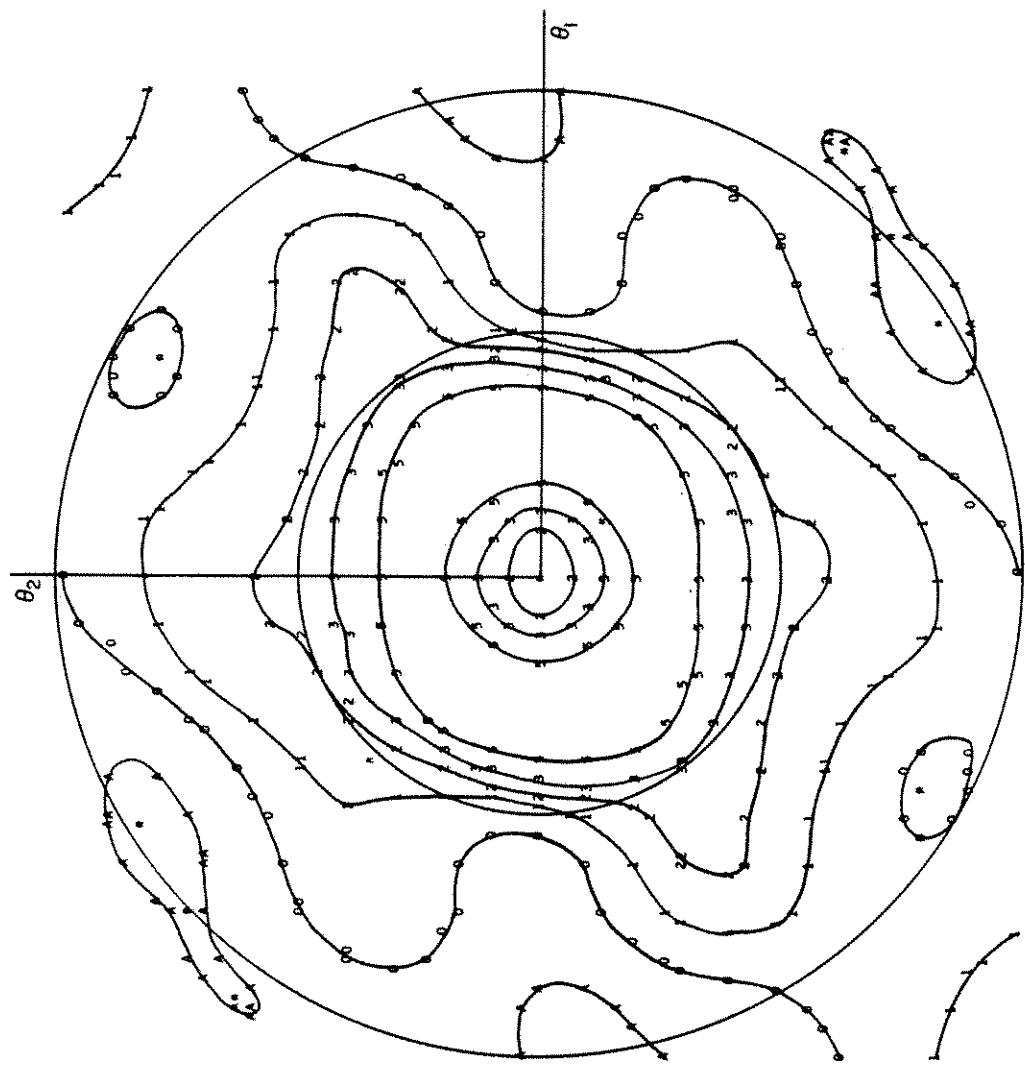


Figure 14f:  $\phi = 45^\circ$ ,  $\delta = 215^\circ$ ,  $\lambda = 6943 \text{ \AA}$ .

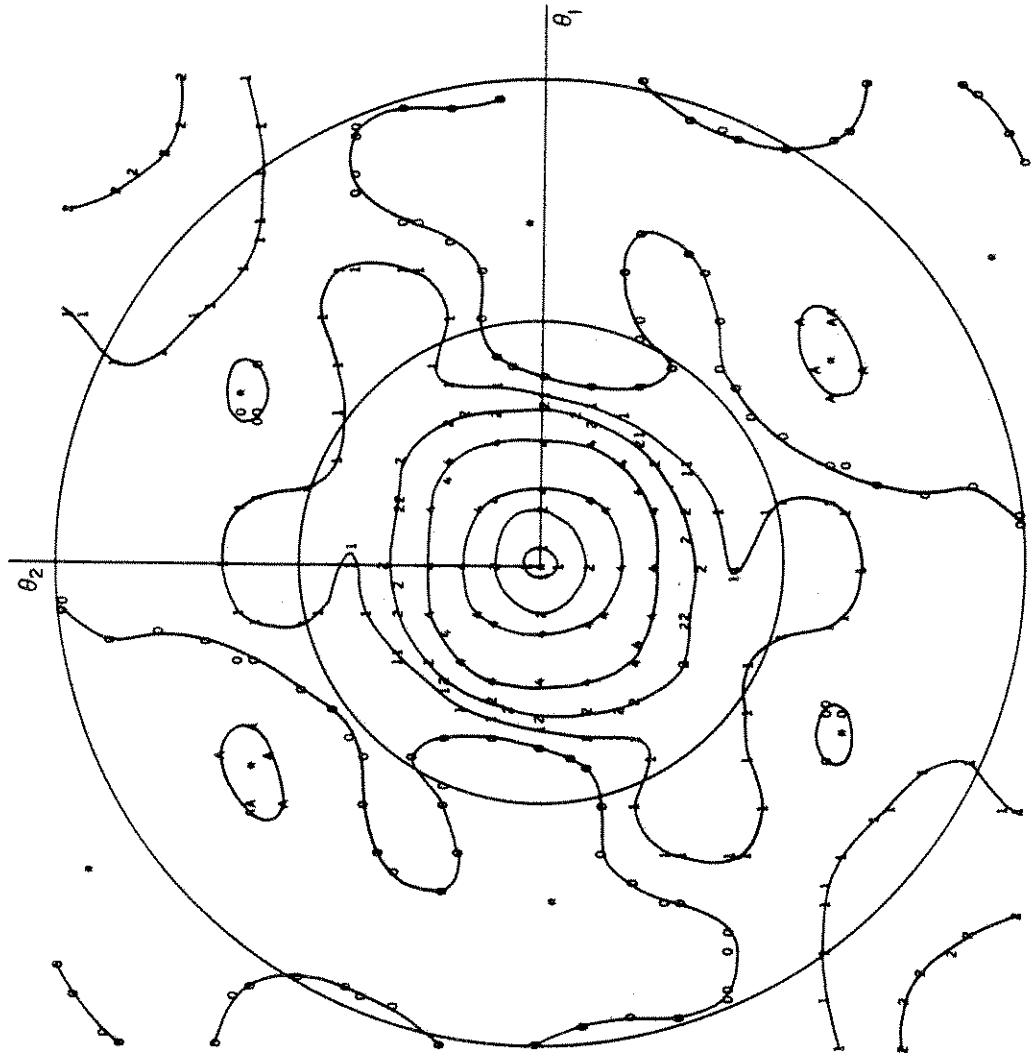


Figure 14g:  $\phi = 45^\circ$ ,  $\delta = 1^\circ 5$ ,  $2^\circ 0$ ,  $2^\circ 5$ ,  $\lambda = 5300 \text{ \AA}$ .

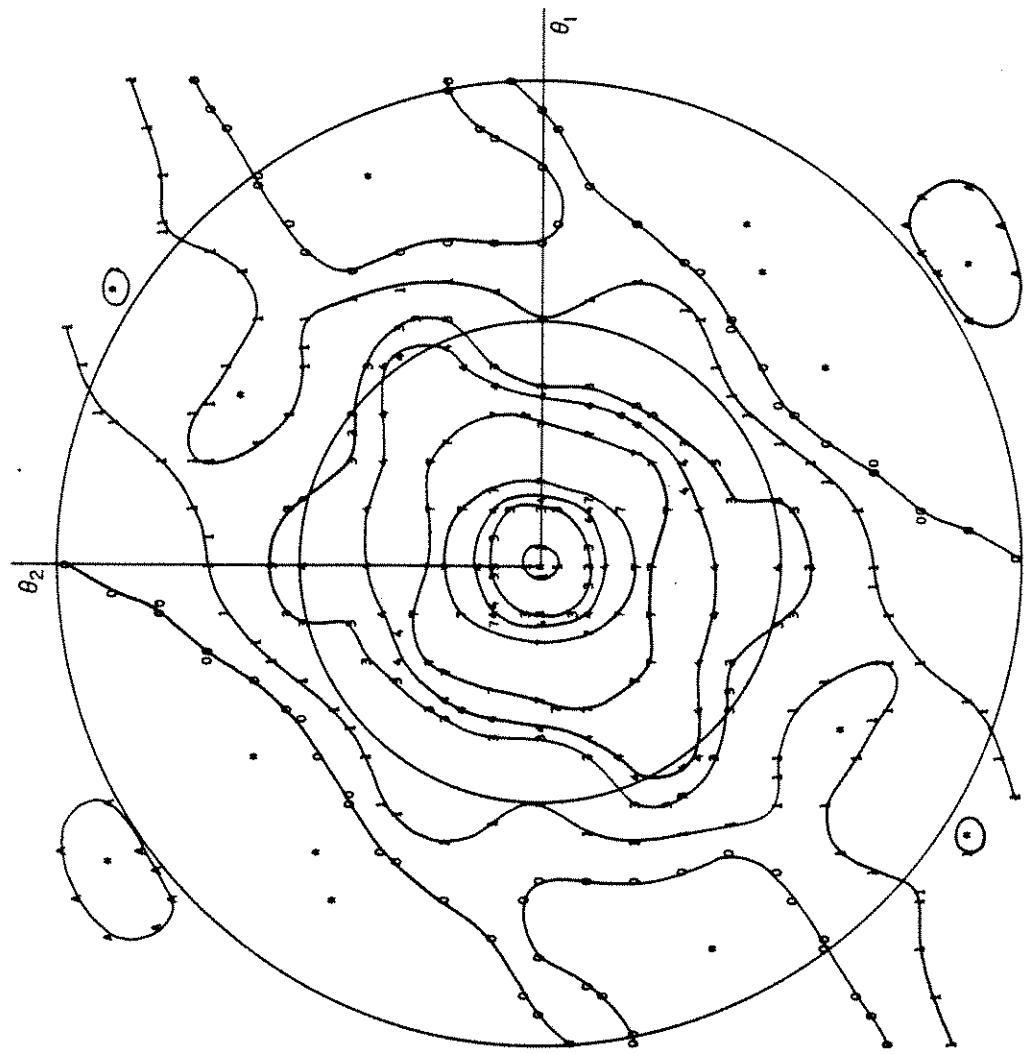


Figure 14h:  $\phi = 45^\circ$ ,  $\delta = 2^\circ 0', 2^\circ 5', 3^\circ 0'$ ,  $\lambda = 5300 \text{ \AA}$ .

Table 21. Half-maximum and half-area range corrections vs. velocity aberration.  
Pulse length = 0.2 nsec,  $\phi = 45^\circ$ ,  $\lambda = 5300 \text{ \AA}$ .

$\theta_1$ ( $\mu\text{rad}$ )	$\theta_2$ ( $\mu\text{rad}$ )	Centroid (m)	$\Delta$ (m)	Half- maximum (m)	$\Delta$ (m)	Half- area (m)	$\Delta$ (m)
<u>a: Dihedral angle = <math>2^\circ 0</math></u>							
0	0	1.2570	-0.0099	1.3037	+0.0007	1.2873	+0.0018
0	25	1.2405	-0.0264	1.2979	-0.0051	1.2597	-0.0258
0	50	1.2698	+0.0029	1.3028	-0.0002	1.2863	+0.0008
25	0	1.2679	+0.0010	1.3021	-0.0009	1.2857	+0.0002
50	0	1.2715	+0.0046	1.3033	+0.0003	1.2893	+0.0038
50	50	1.2218	-0.0451	1.2994	-0.0036	1.2309	-0.0546
<u>b: Dihedral angle = <math>2^\circ 5</math></u>							
0	0	1.2643	-0.0026	1.3028	-0.0002	1.2912	+0.0057
0	25	1.1954	-0.0715	1.2808	-0.0222	1.2104	-0.0751
0	50	1.2708	+0.0039	1.3033	+0.0003	1.2874	+0.0019
25	0	1.2320	-0.0349	1.2943	-0.0087	1.2516	-0.0339
50	0	1.2685	+0.0016	1.3033	+0.0003	1.2846	-0.0009
50	50	1.2501	-0.0168	1.3028	-0.0002	1.2683	-0.0172

The variations in the half-area range correction tend to follow those in the centroid. On the other hand, the variations in the half-maximum correction are remarkably small throughout the diffraction pattern, presumably because the strongest portion of the return comes from the closest part of the array. This is evident in Figure 12t, which shows the incoherent return pulse shape for a 0.2-nsec transmitted pulse at an incidence angle of  $45^\circ$  on the array.

In summary, the maximum systematic error in the range correction is probably on the order of 2 cm. The data presented in Figure 14 and Tables 15 and 21 can be used to obtain a more detailed estimate of the uncertainties that can be expected under various conditions.

## 11. INFRARED TRANSFER FUNCTION

This section gives the reflectivity and range correction for the infrared reflector carried by Geos 3. The dimensions and specifications of the cube corner are given in Section 2, and the position and orientation, in Table 2a and Figure 5.

Since the back faces are uncoated, the cube corner depends on total internal reflection. The minimum incidence angle  $\phi_c'$  at which total internal reflection can be lost is given by the formula

$$\phi_c' = \sin^{-1} (n \sin \phi_c') ,$$

where

$$\phi_c' = \tan^{-1} \sqrt{2} - \sin^{-1} \frac{1}{n} .$$

The index of refraction is  $n = 2.19$  at  $10.6 \mu$  for Irtran-2, which gives

$$\phi_c' = 27.57$$

and

$$\phi_c = \sin^{-1} (1.01348) .$$

Since the sine of  $\phi_c$  is greater than unity, no loss of total internal reflection occurs.

The reflectivity of the infrared reflector is plotted in Figure 15 as a function of the direction of the incident beam, where the angles  $\theta$  and  $\phi$  are as defined in Figure 6. The active reflecting area is normalized to unity at normal incidence, and the area at normal incidence is  $10.6088 \text{ cm}^2$ . The two lower curves, normalized to the center of the Airy disk, give the average reflectivity at  $10.6 \mu$  in the 25- to 50- $\mu\text{rad}$  annulus of

the far-field pattern. The data used to plot the reflectivity curves are listed in Table 22. The fact that the reflectivity is not unity at normal incidence is due primarily to the phase changes resulting from total internal reflection at the back faces. The difference between the reflectivities for the two orthogonal polarizations of the incident beam is largely the result of reflection losses at the front face. The active reflecting area repeats every  $60^\circ$  in  $\theta$ , while the reflectivity in the annulus repeats every  $120^\circ$  in  $\theta$ . For both the active reflecting area and the reflectivity in the annulus, the value for  $30^\circ - \theta$  equals that for  $30^\circ + \theta$ .

The data in Table 22 can be used to calculate signal strengths from the range equation of Section 5. The cross section  $A_S G_S$  is equal to  $ARG_{10.6}$ , where

$$A = 10.6088 \text{ cm}^2 ,$$

$$R = \text{reflectivity from Table 22} ,$$

and

$$G_{10.6} = \frac{A}{\lambda^2} = 9.4418 \times 10^6 .$$

Since the Geos 3 spacecraft is triaxially stabilized, range measurements to the infrared reflector can be accurately related to the spacecraft center of gravity. The relationship of the spacecraft coordinate system to the orbital plane is given in Section 3. If the direction from the cube corner to the illuminating laser is given by a unit vector  $\hat{u}$  in the spacecraft coordinate system and the position of the center of the front face of the infrared reflector is represented by the vector  $\vec{p}$ , then the range correction to the center of gravity of the satellite is

$$\text{infrared range correction} = \hat{u} \cdot \vec{p} - L \sqrt{n^2 - \sin^2 \phi} ,$$

where

$$L = \text{length of reflector (2.475 cm)} ,$$

$$n = \text{index of refraction (2.19)} ,$$

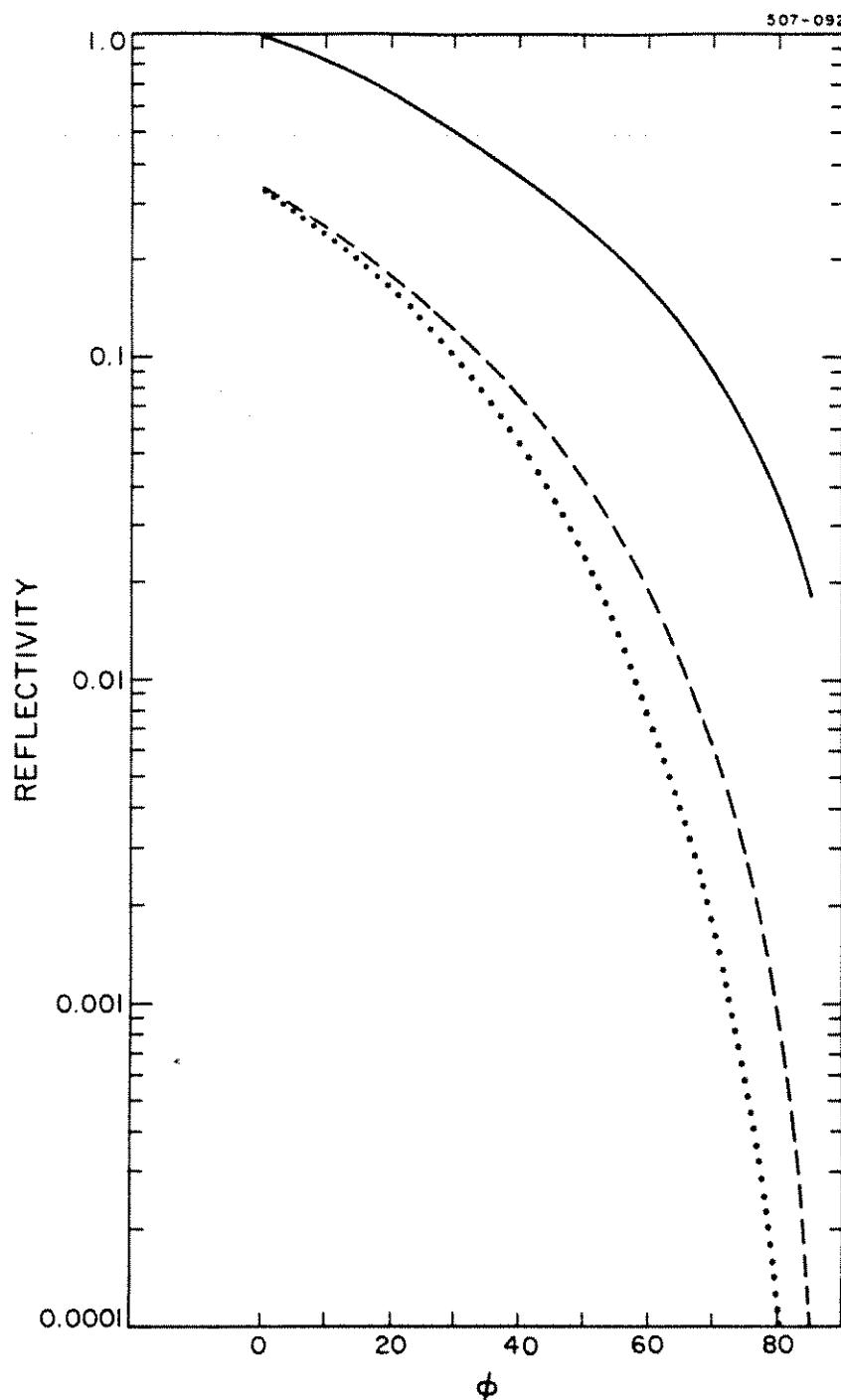


Figure 15. Active reflecting area (solid curve) and average reflectivity in the 25- to 50- $\mu$ rad annulus of the far-field diffraction pattern for the Geos 3 infrared reflector. The dashed and dotted curves represent the electric field vector  $\vec{E}$  parallel and perpendicular, respectively, to the plane of incidence. The incidence angles  $\theta$  and  $\phi$  are defined in Figure 6. a:  $\theta = 30^\circ$ ,  $n = 2.19$ ,  $\lambda = 10600 \text{ \AA}$ .

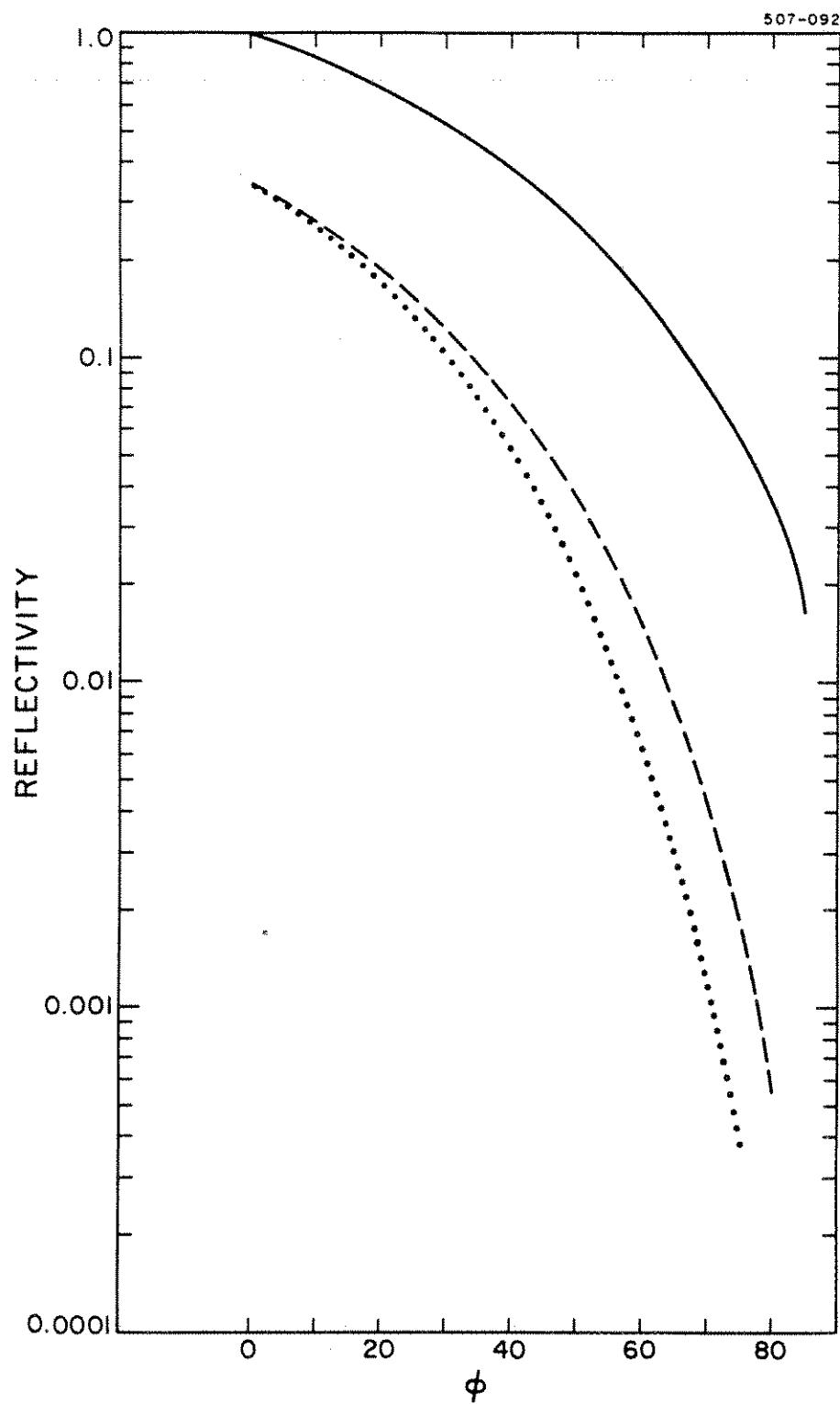


Figure 15b:  $\theta = 60^\circ$ ,  $n = 2.19$ ,  $\lambda = 106000 \text{ \AA}$ .

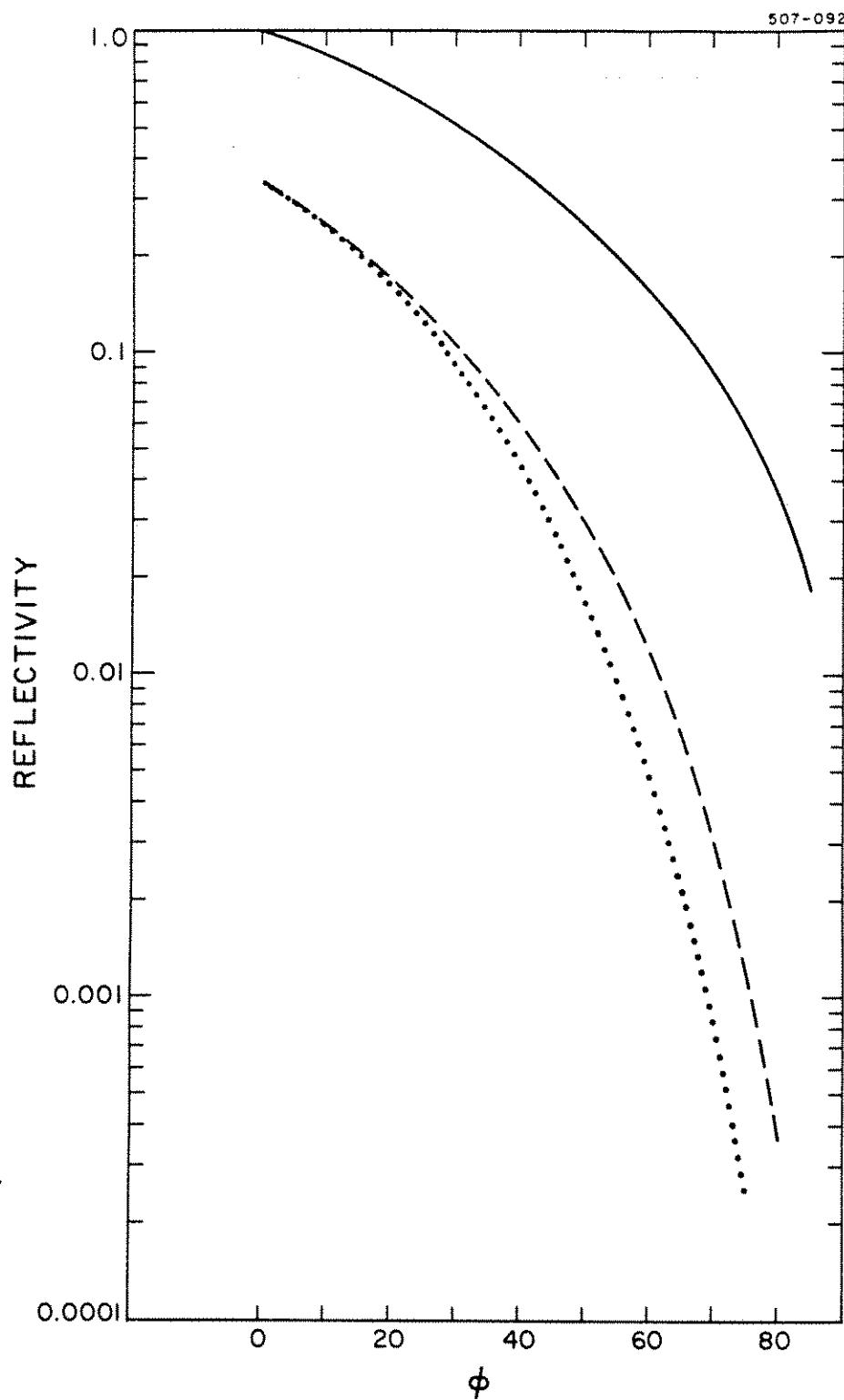


Figure 15c:  $\theta = 90^\circ$ ,  $n = 2.19$ ,  $\lambda = 106000 \text{ \AA}$ .

Table 22. Average reflectivity of the infrared cube corner in the 25- to 50- $\mu$ rad annulus of the far-field diffraction pattern, first with the electric field vector  $\vec{E}$  parallel and then perpendicular to the plane of incidence.

PHI	THETA 30	THETA 60	THETA 90
-----	----------	----------	----------

a:  $\vec{E}$  parallel to the plane of incidence

0	.340065	.340065	.340065
5	.292426	.297813	.291989
10	.249486	.257633	.247418
15	.211208	.219741	.206351
20	.177224	.184329	.168945
25	.147027	.151616	.135432
30	.120143	.121852	.106026
35	.096240	.095302	.080854
40	.075159	.072183	.059898
45	.056883	.052592	.042983
50	.041445	.036564	.029741
55	.028839	.024023	.019605
60	.018952	.014832	.012129
65	.011549	.008563	.006883
70	.006305	.004471	.003442
75	.002862	.001960	.001402
80	.000895	.000598	.000387
85	.000101	.000066	.000039

b:  $\vec{E}$  perpendicular to the plane of incidence

0	.340065	.340065	.340065
5	.291112	.296475	.290676
10	.245002	.253012	.242971
15	.202676	.210896	.198016
20	.164520	.171183	.156836
25	.130607	.134787	.120308
30	.100904	.102466	.089050
35	.075390	.074786	.063341
40	.054071	.052056	.043098
45	.036916	.034256	.027902
50	.023759	.021086	.017057
55	.014245	.011985	.009691
60	.007829	.006230	.005016
65	.003849	.002930	.002298
70	.001622	.001197	.000888
75	.000538	.000390	.000265
80	.000114	.000083	.000050
85	.000008	.000006	.000003

$$\phi = \cos^{-1} (-\hat{Z} \cdot \hat{u}) ,$$

$\hat{Z}$  = unit vector in the direction of the Z axis.

The second term accounts for the optical path length in the reflector.

Since there is only one infrared reflector, no coherent variation of the range or intensity will result from interference. There is also no uncertainty as to the mean point of reflection, as in the case for the optical array, which has cube corners distributed in range from the observer. Because the return pulse has the same shape as the incident pulse, no difference arises among different detection methods. The only satellite-induced range errors are those due either to uncertainties in the position of the reflector with respect to the center of gravity of the satellite or to the orientation of the spacecraft with respect to the plane of the orbit.

## 12. ACKNOWLEDGMENTS

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